Report of the Board of Experts on Street Paving in Philadelphia, Pa.

PHILADELPHIA, July 8, 1884.

HON. WILLIAM B. SMITH, Mayor of Philadelphia:

SIR:—The undersigned respectfully submit the following opinion and report on the subject of street pavements in Philadelphia.

The ordinance, approved June 13, 1884, under which you have requested our opinion on this subject defines the purpose of our investigation in the following words, viz.:

"SECTION 1. *The Select and Common Councils of the City of Philadelphia do ordain*, That for the purpose of obtaining professional advice on the subject of paving the streets of Philadelphia, the Mayor is authorized to obtain from three engineers, distinguished for their knowledge and experience of pavements, a written opinion and report concerning the subject of pavements in Philadelphia, which report and opinion shall be by him transmitted to Councils for their action."

"SECT. 2. The said opinion and report shall be based upon a careful examination of the present condition of the streets of Philadelphia, and shall point out the defects of the present system of paving, and shall specify what, in the opinion of the said engineers, is the best system of pavements for Philadelphia, due regard being paid to durability, economy, smoothness, cleanliness and freedom from noise, and shall further contain an estimate of the cost of such system or systems as they shall recommend."

In order to ascertain "the defects of the present system" we have made a careful examination of the streets, in connection with data furnished to us by the Chief Commissioner of Highways. We find that the present condition of the streets is as follows:

Paved streets	573 miles.
Macadamized streets	44 "
Unpaved streets	443 "
Total	1,060 miles.

On the paved streets the character of pavements is as follows:

Cobble	9,113,925 sq. yds.	93 per cent.
Granite blocks	654,148 " "	6⅔ " "
Asphalt	25,306 " "	⅓ " "
	9,793,469 sq. yds.	100 per cent.

We find further that the cobble pavements, forming 93 per cent. of the total are laid upon a bed of loamy gravel without any sand, that the size of the cobble stones is very irregular, varying from 3 to 15 in. in size, and that the system of repairs consists in farming out certain districts to the lowest bidder, who contracts to keep the district in good order during the calendar year for a lump sum.

We find in regard to granite block pavements, sometimes called Belgian, that the blocks are laid upon a bed of gravel similar to that above described, that the joints are not cemented, that different qualities of granite have been used with different results, and that these pavements have been greatly injured by being frequently torn up for underground pipes and not properly relaid.

We find in regard to asphalt pavements that a certain amount of sheet asphalt has been laid in accordance with what is generally known as the Washington Specifications, and that this pavement looks well, although it has not been laid a sufficient length of time to properly judge of its character; and, also, that asphalt block pavements have been laid in small amounts here and there, some of which look very well, and some, as on Sixth street, near Walnut, very badly.

We also find in regard to the general character of the streets in Philadelphia that they are unusually narrow for a city of its size, the prevailing total width between houses being either 50 or 60 ft., giving only 26 and 34 ft. respectfully for the roadway between curbs; and we also find that these narrow streets are used to an exceptional degree for street railroads, the total length of which amounts to 203 miles, and that where these railroads exist, the carriage-way on each side is reduced to a space of only 10 or 12 ft. in width, which results in confining the travel in such a manner that vehicles follow each other in lines almost as distinctly marked as the lines of the railroad tracks. These exceptional circumstances have a very important bearing upon the character of pavement to be adopted to meet them.

We find that the macadam is used principally in the suburban sections of the city, such as Germantown, Chestnut Hill, etc., where railroad tracks are not so numerous; although in one instance this class of pavement has been used in the heart of the city (part of Twenty-second street) alongside of railroad tracks. The macadam is usually about 10 in. deep, composed principally of a blue gneiss found in the vicinity. Its repairs are farmed out on the same principle as the repairs of the cobble pavements.

Upon the condition of facts above described, we have no hesitation in expressing the following opinions:

First.—That the cobble pavement is the most inferior and the most dangerous to health of all pavements made of stone, and is entirely unfit for use in a large city. It is impossible to maintain its surface in an even condition, because the stones have an uneven bearing, owing to their irregular shape, and its joints are the receptacle for large amounts of street filth, which cannot be removed from them, and which give forth, under the varying conditions of heat and moisture, a variety of vapors and odors which are injurious to health. As it is probable, however, that for financial reasons a certain amount of this class of pavement will have to remain in Philadelphia for some years to come, we are of opinion that its evils can be greatly mitigated by a change in the methods of repairs as follows:

In making repairs the stones should be broken to as nearly as possible a uniform size, and no stones should be relaid whose least dimension is less than 4 in. or greatest dimension is more than 7 in., and they should be laid with the greatest dimension vertical.

The red gravel on which the stones are now placed, which we find by actual test to contain about 16 per cent. of clay, should be used as a sub-foundation only, being spread to the depth of 6 in., and thoroughly compacted by ramming or rolling. On this should be spread a layer of clean, sharp, river-washed sand, free from clay, dirt, or impurities of any kind, and in size not less than ¼th of an inch. This sand should be at least 4 in. in thickness, and will make the only proper bed for the stones. After these have been set, clean, washed pebble should be raked over the surface to fill the joints, and the pavement should then be thoroughly rammed with a heavy rammer.

In making these suggestions, we desire to state, that we recommend that no more new cobble-stone pavements be laid under any circumstances, but we think that if these suggestions are carried out, the existing cobble-pavements can be kept in better order than at present, until such time as they can be replaced with pavements of proper character; and we think that this can be accomplished at less cost than at present, when in consequence of using poor material, the same street has to be relaid two and even three times in the same year. We also think that the system of farming out the repairs by the year is injudicious, because the contract must necessarily lack that element of distinct specification which is the basis of all good work under contracts.

In our judgment it would be much better to make contracts for repairs, by the square yard of work actually done according to exact specifications, the localities where the work is to be performed, to be pointed out by the proper city official.

Second.—In replacing the cobble-stones, or in laying new pavements, we advise that your choice be restricted to one of the following classes, viz.; granite blocks, sheet asphalt, or in exceptional cases, asphalt blocks, the selection among these three being determined by the character of travel, and other conditions which will hereafter be referred to. All of these pavements are perfectly water-proof, which is an indispensable condition for a good pavement.

We are aware that at the present time large amounts of wooden pavements are being laid in London and in Paris.

As laid in those cities, upon a foundation of concrete of Portland cement and with blocks of seasoned wood especially treated with preserving compounds—they undoubtedly make a more durable road covering than the wooden pavement which proved so signal a failure in this country several years ago. But according to information received very recently from the French Engineers, it is expected to renew the wood every four or six years, depending on the amount of travel. The first cost of the pavements now being laid in Paris is equivalent to about four dollars per yard, and the contract price for repairs and maintenance is forty-nine cents per yard per annum, the contract being made for eighteen years. This brings the total cost during eighteen years to twelve dollars and eighty-two cents, which is about three times the cost, during the same period, of the pavement which we recommend. On account of its cost, both for construction and maintenance we do not recommend the wooden pavement for the City of Philadelphia.

We advise that the granite block pavement be used exclusively on all the streets where the distance between rail and curb (or, if there be no railroad, between curb and curb) is less than 20 ft., also on all streets in the business section of the city where the travel is unusually heavy—say more than fifty trucks or other heavy wagons per hour, and on all streets, without regard to width or traffic, where the grade is steeper than three in one hundred, except those streets where asphalt blocks are admissible, as hereinafter specified.

We advise that sheet asphalt be laid in spaces near public buildings where quiet is particularly desirable, provided the space is sufficiently wide (more than 20 ft.) and the grade not too steep (less than three-one-hundreths) also on streets which are occupied exclusively by dwelling houses and where there are no railroads. As instances of such localities we would cite the space around the new Public Buildings, and on Broad Street Twenty-first Street south of Market, portions of Locust Street in the vicinity of Rittenhouse Square, Diamond Street, and other streets of the same character on which there are no railroads. In laying asphalt along railroad tracks, in broad spaces like that surrounding the new City Buildings, a space not less than 1 ft. in width next to the track should be paved with granite blocks, the ends of the blocks toothing into the asphalt.

The asphalt block pavement is somewhat inferior in wearing qualities to the sheet asphalt, but it has great advantages in being cheaper, and in requiring no special plant or skilled labor to lay it. It is well adapted provided the blocks are properly made, to streets of light travel, occupied solely by residences; but it is proper to state that there is great difference in the quality of these blocks, as ordinarily made, and corresponding risk in adopting them. For heavy traffic they have usually proved a failure. This pavement would be suitable for many of the residence streets of West Philadelphia, but it should not be used on streets where there are railroad tracks, or where the grade is steeper than four in one hundred.

For the suburban streets of Germantown, Chestnut Hill and similar sections, we recommend that macadam continue to be used, at least until the travel on them becomes very much greater than it is at present.

Having thus indicated the general character of the pavements and the conditions which govern the selection and use of each, we will now speak more in detail of the manner in which they should be constructed and laid.

THE GRANITE BLOCK PAVEMENTS

Should be laid on a foundation of concrete 6 in. in thickness; or upon a bed of strong clean gravel of the same thickness, formed to the cross-section of the street, and thoroughly compressed by rolling with a steam roller such as is hereafter described, and all subsidence made good by additional material. In either case the blocks should be bedded in 3 in. of sharp washed sand, free from clay or other impurities; the joints should be filled with a preparation of clean, dry pebbles (heated if laid in damp weather), and the coal tar product known to the trade as No. 5.

In regard to the foundation, we are of opinion that for ordinary traffic the concrete is unnecessary, provided the work is properly done. Well compacted dry earth is an excellent foundation, provided it is kept dry; and if the joints are properly filled with tar and gravel the pavement becomes absolutely water proof and no settlement can occur. If, however, the work is not properly executed and the joints not properly filled then water will penetrate to the foundation, and settlement and inequalities will occur. There can be no doubt that the concrete foundation provides against all contingencies. Its use increases the cost of the pavement by about eighty cents per square yard. On streets of the heaviest travel it would doubtless be best to incur this extra expense, although, as previously stated, we do not consider it necessary where such an earth foundation as we have described is kept perfectly dry, and the traffic is not very heavy.

In regard to the quality and size of the blocks, we recommend the Quincy granite as a standard, and all blocks should be equal to this in toughness and hardness, should be of uniform texture, and free from weathering. Hard, basaltic stone, that will take a polish under travel, should be rejected, as should also the softer qualities of granite, and all other gneiss and other laminated stones. The blocks should not be less than 3 nor more than 4½ in. in thickness, 6, 7, or 8 in. in depth, according to the amount of travel, and in length about one and a quarter times their depth. A pavement with narrow blocks affords a firmer footing to the horse, and is less noisy than one with wider blocks; but the thickness cannot be reduced below 3 in. without impairing the strength of the block. Variations in length may be permitted to the extent of two or even 3 in. but in depth the blocks should be as nearly as possible uniform; no variation greater than ½ in. being permitted. It is impossible to lay a good pavement with blocks of unequal depths, for under travel the blocks will find a level bearing underneath, and all the inequalities will be on the surface. The blocks should be carefully sorted as to width, and those of the same width be used in the same portion of the street. Each block should be regular in shape, with rectangular edges and smooth faces, having no projections nor depressions greater than ½ in. We advise that the blocks be laid invariably with tar-cemented joints, so as to make the pavement water-proof. No open-jointed pavement should be laid in a city, on account of the large spaces between the blocks giving access into the soil below for the urine and other foul waters of the street, and giving out fumes not only to the street in summer time, but, through heating and ventilating systems, to the interior of houses in winter. With blocks 6 in. deep and regular in shape, so that the joints will not be too wide, about 3½ gallons of tar will be required to the square yard, and the cost of this is about twenty-five cents. The advantages of the water-proof joints are fully worth this price.

We recommend that the city purchase the blocks which it may intend to lay several weeks or months in advance, so that they may be carefully inspected on delivery, and all blocks which do not conform to the specification can be rejected. Separate contracts can then be made for laying the blocks after they have been inspected. We estimate the cost of granite block pavements, laid with tar joints in the manner we have described, as follows, per square yard.

	6 in. deep.	7 in. deep.	8 in. deep.
Cost of blocks	$1 80	$2 00	$2 25
Cost of laying	80	85	90
Total	$2 60	$2 85	$3 15

From these prices not less than fifteen cents should be deducted, if the old cobble now on the streets is to be given to the contractors, and 80 cents should be added to them if a concrete foundation is used.

ASPHALT PAVEMENTS.

Under the name of asphalt, a large variety of mix-

tures have been laid as pavements, but all those which had any value at all belonged to one of three classes, viz.:

1st. The Asphalte comprimé, which is largely used in Paris and other European cities. This is made from an amorphous limestone, naturally and intimately impregnated with bitumen, found in the Vosges Mountains, and in Sicily. It is reduced to powder, heated, placed on a concrete foundation, and then thoroughly compressed by ramming and rolling.

2d. The American asphalt mastic, which is the standard pavement at Washington. This is an artificial compound, made of refined Trinidad bitumen, powdered stones, and sharp sand. The mastic is placed on a concrete foundation when hot and plastic, and thoroughly compressed by rolling.

3d. The coal-tar concretes, improperly called asphalt, in which the foundation was of broken stone and coal-tar, and the top surface of sand, or fine pebbles, and coal-tar made into a mastic, spread and rolled substantially as above.

All three of these classes of pavements, when manufactured with skilled labor and laid with proper care, have resulted in good roadways.

The coal-tar pavement is not recommended by us, for the reason that the cementing substance is a product of gas-tar, obtained by interrupting the destructive distillation of that compound, after it has reached a certain point. When placed on the street and subjected to atmospheric influences, a slow and gradual oxidation takes place, by which the tar loses its cementing qualities and becomes inert. The particles of sand then lose their cohesion, and the pavement rapidly disintegrates.

The price of the Asphalte comprimé in this country at present would not be less than three dollars and fifty cents per square yard. The American asphalt mastic can be laid at a profit for two dollars and twenty-five cents. The Asphalte comprimé is at times very slippery—an objection to which the American pavement is less subject. There has not yet been sufficient experience as to the comparative cost of repairs of these two classes of pavement to state definitely which is the more durable. Therefore we recommend, at least until further experience, that the American asphalt be used in Philadelphia, in such localities as we have indicated.

A foundation of concrete of the best American hydraulic cement, six inches in thickness, is indispensable for any asphalt pavement. It is, in fact, the pavement itself, the asphalt surface being merely a cushion to break the force of the travel.

The proper preparation and laying of both the Asphalt comprimé and mastics is so largely a matter of expert manipulation, besides the necessity for purity in the material, that rigorous specifications are liable to be used by an incompetent or dishonest contractor as an excuse for bad work. In order to obviate their difficulty, it has been the practice for several years in London and other European cities to let contracts for this class of pavement only on satisfactory bond or deposit for maintenance during a period of not less than fifteen years at a specified rate per square yard per annum, the amount of subsidence or dilapidation calling for repairs being rigorously specified, so that it can be clearly understood by the residents on the street as well as the parties to the contract. This system, although it has never been introduced into this country, has met with such uniform success abroad that we recommend it as worthy of the most careful consideration and a full trial.

We recommend that no proposition be entertained looking to the covering of the cobble stones with asphalt or any other compound. Such work will result in nothing but failure, and will create a nuisance on the streets. The reason of this is that asphalt compound, having no transverse strength of its own, requires an absolutely rigid and unyielding foundation. Cobble stones do not fulfill this condition.

ASPHALT BLOCKS.

These blocks are made of Trinidad bitumen and small particles of lime-stone, mixed together in certain proportions and pressed in a mould under very heavy pressure. They are ready for laying as soon as received from the factory. The size of the block usually manufactured is 12 in. long, 4 in. wide, and 5 in. deep, and we see no reason to change these dimensions. In regard to its foundation, the same remarks apply as already made in regard to granite blocks, i, e., if the foundation is well compacted and perfectly dry, a concrete bed is unnecessary; but the concrete prevents the chance of poor work. The blocks are of such uniform size that the joints are extremely narrow, and the asphalt on the sides soon unites so as to make the pavement waterproof. Asphalt block pavements can be laid at a profit for two dollars and ten cents per square yard on a foundation of gravel and sand. From this should be made the same deduction for old cobble, and the same addition for concrete foundation, as previously noted.

MACADAM.

In laying new macadam roads in the suburban districts, we recommend that, if the ground be at all springy or damp, a bed of sand or of blast furnace slag, six inches in thickness, be laid as a foundation, and thoroughly rolled. This will provide most effectually for the drainage in the wet season.

The macadam proper should be ten inches in thickness, spread in two layers, each of sufficient thickness to be five inches thick when thoroughly compressed. This compression should be obtained by a steam roller weighing not less than ten tons, and employed for not less than ten hours on each one thousand square yards of each layer. As the use of heavier rollers than can be drawn by horses is necessary for the best type of macadam roads, and as the expense of purchasing a steam road-roller will deter contractors, without assurance of more than one season's work, from bidding on macadam where such purchase is necessary, we recommend the purchase by the city of three rollers, weighing not less than ten gross tons each and not less than two tons per foot run. We estimate the cost of such rollers at about five thousand dollars each. These rollers can be used for compacting foundations for pavements, as mentioned above, as well as macadam roads, being rented to contractors under proper regulations. In the spring, when the roads are soft, it will be found advantageous to go over all of them, rolling down any projecting stones and bringing the surface to proper shape with fresh materials where any depressions occur, without waiting for the road to be worn out. This, on roads of light travel, with cleaning and watering, will probably be sufficient until fall; on roads of constant and heavy traffic, a roller and store of broken stone should at all times be at the disposal of the engineer in charge, so that the surface can be kept perfect.

For new roads, the bottom layer, which may be of gneiss or lime-stone, broken to pass through a four-inch ring in their largest dimensions, should be placed on a thoroughly compacted bed, as before specified. In rolling this course as above specified, a watering cart and trap screenings should be on hand for use in case the stones begin to roll on each other. When thoroughly compacted, the top course, which should be of tough trap-rock, broken to pass over a one and a quarter inch hole and to pass through a two and a half inch hole, and free from flat pieces or spawls, should be rolled with the same precaution as to water carts and screenings, as above, till thoroughly compacted; when fine, dry screenings should be slowly spread, and rolled in until all interstices are thoroughly filled and a coating of powdered screenings one-quarter inch thick remains on top of the stone, when the road should have a plentiful supply of water from a sprinkler directly in front of the roller, which should be kept in motion till all the surface behind it is puddled or has a mottled appearance, when a light coat of screenings will finish the road, and after a few hours drying it can be thrown open to traffic.

The intention of this is to, first, afford a cheap foundation, and, secondly, to make a hard, compact, and, as nearly as possible, homogeneous wearing surface. For this reason trap screenings were specified in the lower coat, as softer screenings, if allowed on the ground, will be worked into the top coat. Any soft material used as "blinding" will reduce the cost and labor of rolling, but will make a softer, dirtier, and more perishable road. On country roads the superior economy, resulting from the use of clay or other soft material, may justify it, but on suburban roads all soft material should be rigorously excluded.

A macadam road should be maintained by thoroughly wetting any depression and rolling in stones from one to one and a half inches in size, in order that general repairs, except on heavily traveled roads, should seldom be necessary. The dust and debris of a macadam road should not be swept off in dry weather, unless water enough can be afforded to make a very liquid mud. When that is attained, naturally or artificially, a soft revolving broom should be used, with such draft that the heavy debris is not removed. When there is an inconvenient amount of trash on the road, the same broom, with a lighter draft, can be used to remove it. The road should not be scraped, and should be let alone when the mud is not sufficiently fluid.

We estimate the cost of a macadam pavement laid in the manner we have described, at one dollar and seventy-five cents per square yard.

In conclusion, we submit the following recommendations of a general character:

All contracts for pavements (excluding macadam) should contain a clause by which the contractor guarantees to keep the pavement in good repair for a period of not less than five years from the date of its acceptance by the city, and to insure a compliance with this guarantee, the city should retain 10 per centum of its cost until the expiration of the five years term.

No pavement, no matter how well laid, can be kept in proper order if it is constantly disturbed for the purpose of laying or repairing underground pipes. In order to avoid this as far as possible, all drains, gas, water and other pipes, should be laid, or, if already laid, should be thoroughly repaired, before the pavement is put down. Such openings in the street as subsequently become unavoidable, should be made only by permission of the city official in charge of the streets and under his direct supervision; and before such permits are granted, the applicant should be required to pay the estimated cost of repairing and relaying the pavement, and these repairs should be made under the immediate direction of the same official, who should be held responsible that they are made properly.

The crown or transverse section of the pavement should be the arc of a circle, with versine about one-eightieth of the chord, or say for

Streets 26 feet wide, crown 4 inches.
Streets 34 feet wide, crown 5 inches.
Streets 50 feet wide, crown 7 inches.
Streets 70 feet wide, crown 10 inches.

In wider streets these may be slightly reduced when the longitudinal slope exceeds three in one hundred.

The distance from top of curve to surface of pavement at the curb should be between 5 and 7 in. depending on the width of the street.

In cases like that of Locust Street, between Sixteenth and Seventeenth Streets, where the ground is soft and full of springs, we would advise that "blind" or broken stone drains be laid under the foundation, these drains being connected at their lower ends with drain pipes leading into the nearest sewer or inlet. A concrete foundation should be laid on all such streets as a further protection against settlement. No sewer pipes intended to carry house drainage should be laid with open joints for the purpose of draining the soil. Such pipes would speedily pollute the soil and produce sickness.

The ordinance under which we have made this report requires that the report shall "contain an estimate of the cost of such system or systems as we shall recommend." We have already stated that the cost per square yard of the standard pavements which we recommend, is as follows:

7 inch granite blocks on concrete foundation,	$3.65
6 inch granite blocks on gravel foundation,	2.60
Sheet asphalt on concrete foundation,	2.25
Asphalt block on concrete foundation,	2.90
Asphalt block on gravel foundation,	2.10

Although the existing granite block pavements are not cemented in the joints, yet they are so much better than the cobble pavements, that it is not likely that any plans for relaying them will be considered at present. This leaves the 535 miles of cobble pavements, containing in round numbers 9,000,000 square yards. Of this a length of 203 miles is traversed by street railroads, between the rails of which we would advise that the cobble be allowed to remain for the present. This reduces the area by about 600,000 yards, leaving 8,400,000 yards to be repaved. It is not probable that more than 80 miles of streets, say 1,400,000 yards—will fulfill the conditions which we have named as limiting the use of asphalt pavements, and of this not more than one-fourth to one-third should be asphalt block.

We have then 7,000,000 yds. remaining for granite blocks, and of this perhaps 1,000,000 yds. in the heavy business streets, should be deep blocks laid on concrete.

This gives the data for the following approximate estimate, viz.:

1,000,000 sq. yds. granite block at	$3.65	$3,650,00
6,000,000 sq. yds. granite block at	2.60	15,600,000
1,100,000 sq. yds. sheet asphalt,	2.25	2,475,000
300,000 sq. yds. asphalt block,	2.10	630,000
8 400,000 sq. yds.		$22,355,000

From this should be deducted the value of 8,400,000 yds. of cobble, at 15 cts., $1,260,000, leaving the net cost $21,095,000.

It is estimated that $2,000,000 could be advantageously expended in each year, in laying about fifty miles of improved pavements so that the cobble stone would be entirely replaced in between ten and eleven years.

These estimates are necessarily general and approximate only. They are given merely for the purpose of stating what will be the probable ultimate cost of replacing the cobble stones. Our estimate of prices per square yard is based upon the actual cost of similar work in other cities during the past few years, and it may be relied upon as reasonably exact, at the present prices of labor and materials.

Respectfully submitted,

(Signed) Q. A. Gillmore,
F. V. Greene,

The undersigned agreeing with the above, wishes to add a recommendation that in the case of all pavements, except those laid on concrete when the ground is wet or soft, a layer of fine sand or blast furnace slag be placed or rolled under the bed of gravel specified, with the purpose of preventing the subsidence of the gravel into the clay.

Also, for the lanes or alleys in the old part of the city, where water is discharged into the gutters, the use of rock-asphalte mastic made from either one of the following brands, viz.: *Val de Travers or Neuchatel, Seyssel*, or the mastics of the *United Limmer Company*. These mastics when properly laid are not disintegrated by hot or other water, and can be laid so hard that wheels following in one track will not injure them. This pavement can be laid on six inches of concrete, one and one-half inches thick, for $2.75 per sq. yd., and the gutters will be so smooth that water will not lodge in them as at present.

Very respectfully,

(Signed) Edward P. North.

The dam of the city reservoir in North Bridgeport, Conn., is said to be in danger. It has recently been raised four or five feet and material and men are on hand to still further raise it.

Concrete for Marine Constructions.

In the Aberdeen Breakwater and Harbor Works at Brest, concrete blocks of moderate dimensions were adopted, weighing in the former case from 7½ tons to 24 tons, and in the latter 100 tons each.

As an example of the use of extremely large blocks, a short reference may be made to the manner in which a considerable length of deep water quay wall has been constructed at Dublin. The position of the works is extremely well sheltered, and interruption due to bad weather are consequently reduced to a minimum. The contents of each block averages about 103 cu. yds., which at 14 cu. ft. to the ton, gives a weight of about 370 tons. Each block is about 29 ft. in height, and is built in wooden casings to the section of the wall, battered on the face, and with horizontal offsets at the back, each block representing 12 lineal feet of quay wall built to a level of 3 ft. above low water. The blocks consist of rubble masonry set in cement concrete, gauged in the proportion of one part Portland cement to seven parts sand and very coarse gravel or shingle, and are built upon a specially constructed wharf at a short distance from the site they are intended to occupy permanently. A block takes from three to four weeks to build, and is considered sufficiently consolidated to move after ten weeks. A large iron pontoon or float, also of special construction, is used for lifting and transporting the blocks, This pontoon (see Fig. 1) is 130 ft. in length, 48 ft. wide, and 14 ft. deep, and is provided with two pairs of massive and lofty shear-legs, one pair forward, the other aft. The cross-head of the former, which is 54 ft. above the deck of the pontoon, carries two sets of heavy four-sheaved pulleys, through each of which, and a corresponding pair of hanging pulleys, a pitch chain is reeved. The lower pair of pulley blocks are furnished with projections which grip the upper tee-heads of four round iron suspension bars passing through the masonry, and provided with tee-heads on their lower extremities, bearing on cast-iron girders or washers built into the bottom of the block.

The after shear-legs support a counterbalance consisting of a tank filled partly with concrete and partly with water; the latter, by being pumped into or out of the tank, affords the principal means of lifting and setting the blocks in their position. The first part of the lowering, however, is accomplished by means of the pitch chain already mentioned, which is connected to powerful crab winches on the deck of the pontoon. These winches, together with a centrifugal pump and several surging heads, are driven by a 14 nominal horse-power engine.

The foundation for the blocks is prepared first by dredging, the excavation being subsequently completed and the bottom very carefully levelled by means of a large diving-bell (see Fig. 2), which is also of special construction and consists of a cast-iron chamber 20 ft. square and 6 ft. 6 in. inside height, with a vertical tube and air lock. The bell or chamber is suspended from a suitable shears on an iron float containing the engine, air-pumps, winches, etc. With a diving chamber of this description, the bottom—which, when ready for the block is about 26 ft. below low water, and has an area of about 250 sq. ft.—can be levelled with the great accuracy absolutely necessary for the satisfactory setting of such large blocks in quay walls where irregularities in the face are inadmissible.

With the aid of the special appliance above described, an average of 400 lineal feet of blocks can be laid in still water per year, which is equivalent to 6500 cu. yds., or allowing 300 working days to the year, about 22 cu. yds. per day. The actual progress has been somewhat less (about 364 lineal feet per annum) owing to slight interruptions of various kinds.

The cost of the special plant required for the lifting, transporting, and setting of the blocks has been as follows:

	£
Floating shears	18,783
Block wharf	4,610
Chain testing machine, moorings, and sundry little items, about	2,607
Total	26,000

The cost of the blocks standing on the wharf is given as 16*l.* per lineal foot, or about 19s. 8d. per cubic card for labor and materials.

Lifting, transporting, and setting the blocks, including maintenance of shears, float, and block wharf, also shifting moorings, etc., has been 3*l.* 10s. per lineal foot of block, or, say, 4s. 4d. per cubic yard. If interest at 5 per cent. per annum be added to the cost of the plant (26,000*l.*) and one-fourth the first cost deducted as the approximate selling value of the plant, at the end of five years, the proportion of cost of special plant will be 16s. per cubic yard, and similarly at the end of ten years, 10s. per cubic yard, and at the end of fifteen years 8s. per cubic yard.

Summarising these results for convenience of comparison, the cost of the various items

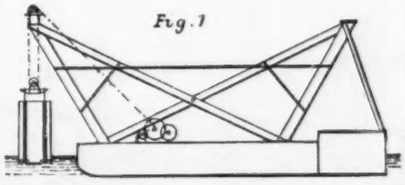


Fig. 1

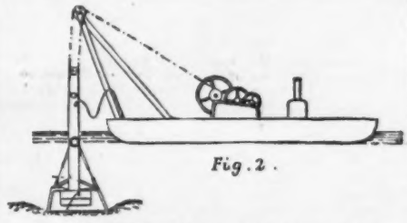


Fig. 2.

connected with the block-work is as follows:

	£ s. d.	
Quantity of block-work deposited in place per year	6500	c. yds.
Approximate cost of special plant required for manipulating the blocks	26,000*l*	
Cost of blocks, materials, and labor	0 19 8	p. c. yd.
Lifting, transporting, and setting of blocks, including maintenance of float and block-wharf	0 4 4	"
Proportion of cost of special plant at end of five years	0 16 0	"
Proportion of cost of special plant at end of ten years	0 10 0	"
Proportion of cost of special plant at end of fifteen years	0 8 0	p. c. yd.
Total cost at end of ten years' work, exclusive of cost of levelling foundations	1 14 0	"
Total cost at end of fifteen years' work	1 12 0	"

The large size of the blocks used at Dublin involved the levelling of the foundation with great care and accuracy; for this purpose the large diving-chamber before described has been found to work satisfactorily its cost, however, was considerable, amounting to 5454*l.*, which would preclude its use on any but works of considerable extent. The cost of excavation, including the maintenance of bell, float, and machinery, is given at 3*l.* per lineal foot of block, which is equivalent to about 3s. 8d. per cu. yd. of block-work. If to this is added the proportion of the cost of this item of special plant, after fifteen years of continuous work, which amounts to about 1s. 8d. cu. yd. of block, the total cost of excavating and preparing the foundations will be about 5s. 4d. per cu. yd. of block-work, or about 51*l.* per block.

The details of the system adopted at Dublin have been most carefully elaborated by Mr. B. Stoney, the engineer of the works, from whose valuable paper on the subject most of the preceding information has been extracted.

The breakwater at Kustendjie, on the western shore of the Black Sea, affords an instance of the successful use of 30 ton concrete blocks. Each block is 6 ft. high by 5 ft. wide, and of a length equal to the width of the breakwater, which is 18 ft. at the bottom and 12 ft. at the top; the blocks are laid with a slope towards the shore of 45 deg. from the vertical, somewhat similar to those used in the Manora breakwater at Kurrachee, and laid on a similar foundation of loose rubble stone. The concrete used at Kustendjie consisted of the following:

	Parts.
Broken stone	5½
Sharp sand	2½
Portland cement	1

Taper bolts 2 in. in diameter were used to lift and lower the blocks, the nuts and washers remaining permanently in the block; this arrangement, however, does not compare favorably with that adopted at Dublin and elsewhere. The blocks were lifted and set, by means of a timber gantry carrying a travelling winch. The foundation was first roughly levelled and the operation subsequently completed by divers with the aid of iron set squares. The cost of this breakwater is not given, so that the method of construction employed cannot be compared in this respect with those already referred to.

The blocks were lowered into their places when from twelve to fourteen days old.

Irrigation in South Africa.

The great enemy of the South African colonist is drought. He lives on a soil capable of producing enormous crops and of supporting endless flocks of sheep, and yet every few years his crops fail, fresh vegetables rise to prices unheard of even in Covent Garden, and his sheep die by hundreds and thousands. In fact he lives by and on the rainfall, and a record of its amount is a fair index of his material condition; when it is abundant his wealth increases, his herds multiply, and he enjoys all the benefits of a teeming vegetation; when it is scanty his sheep have to be driven far to seek for pasturage, his fields yield a poor return, and his life is one of labor without recompenses; while, if it fail, as unfortunately it often does, ruin comes and takes up its lodging with him. Unfortunately the first picture, that of abundant rain, is very seldom realized, the climate, like most other climates, having a tendency to develop in the least pleasant direction. This fact is shown by the large import of provisions which amounted to 730,000*l.* last year, in a country whose resources should render it one of the world's granaries. And yet there are drier climates than South Africa which produce enormous harvests. The sands of the Egyptian deserts, and millions of acres of the black loam of India are made exuberantly prolific by the simple application of water raised by the patient Hindoos and much enduring fellaheen by aid of primitive appliances, which have descended to them through a long line of generations. In Algeria the French have reclaimed whole tracts, and even in the desert itself they have created similar oases as resting-places for the caravans. And now the South African colonists are asking themselves if something of the same kind cannot be done by them, so that they may avail themselves of the rich soil, and ardent sunlight which are so abundant in their land. For years the more advanced party have been hammering at the doors of the Government to obtain official aid in exploring the resources of the colony, and breaking down the dull monotony of its wool culture. They ask a department which shall take charge of agriculture and irrigation, and shall lend its aid and countenance to all schemes for the introduction of new animals and products. They have got an Irrigation Act, but its administration is so shackled by red tape and officialism, that it is of but little avail, and has not been

taken much advantage of. Seeing that effectual Government assistance is not forthcoming, a scheme has been floated to undertake a piece of irrigation work by private enterprise on the Oliphant's River, Clanwilliam District, where a moderate outlay may be confidently expected to give a most abundant return.

The drainage area of the Oliphant's River is approximately 21,000 square miles, and it flows between banks which are unequalled for fertility anywhere in South Africa, the soil being formed of silt deposited from the flood waters of the Doorn, Troe Troe, and Holle Rivers. The deposit is of great depth, and is found in horizontal layers of unequal thickness proportioned to the magnitude and duration of the floods which deposited them. If it be submerged in May or June for twenty-four hours it usually returns to the cultivator one hundredfold. It is related by one of the chief nhabitants that his father once sowed on the delta of the Troe Troe River one quarter of a muid of wheat, and reaped one hundred, and the next year he cut another hundred muids without sowing. The climate is a very dry one, and the region is practically rainless.

Yet with all these advantages the inhabitants are sunk in poverty and wretchedness. In the course of years the river has widened and deepened its bed and now keeps to its channel instead of spreading over the adjacent land. There is abundance of water but no means of bringing it in contact with the springing seed, and hence thousands of acres of the richest soil in South Africa are lying waste and unproductive, and its nominal cultivators scratch a precarious living on the low-lying patches by the river's bank, which are still below the flood line. A proper irrigation scheme would reclaim a tract of land, which is estimated by Mr. Balfour at 8642 acres, and by others who have gone over the ground, at nearly double that amount. The crops that can be gathered with a regular supply of water are enormous, when the cultivation is carried on with industry and inteligence. In some of the South African towns the presence of German emigrants has transformed the aspect of the market. These people, possessed of no capital but thrift and perseverance, settled along the river banks and commenced market-gardening, raising the water by mechanical means, and in a few years they established a new industry. It is also related that the owner of a two-acre lot of irrigated land at Warrington on the Vaal River, 50 or 60 miles from Kimberly, sold produce to the value of 780*l.* between October 17, 1883, and January 14, 1884, all from the two-acre lot. Of course vegetables and fruit were very dear then at Kimberly, but they were dear because the land was short of water, not because it was deficient in fertility.

It is scarcely to be feared that the present scheme will fail of achievement for want of financial support. The location is well chosen and contains all the elements required to secure success. The scheme is in its essence colonial; upon its success or failure will depend many others of a like nature, which will not only add to the revenue of the country, but will also bring into it considerable capital from the outside. It is not sufficient that it should not be a failure; it could scarcely be that under the favorable conditions in which it is situated, but it must also be a great success in order that other districts less happily situated may be encouraged to follow the example. Affairs at the Cape are at this moment under a cloud; the inflation produced by the war expenditure has been followed by its natural reaction, the diamond mines give signs of being exhausted, traders are drawing in their operations, and are watching the course of events. At such a time a scheme for increasing the natural resources of the country is most welcome, and will receive not only the warm approval of the most enlightened and far-seeing of the inhabitants, but also the material support of capitalists in the mother country.

The Proper Sizes for Culverts.

An old practical rule on this subject, for which good authority can be given, is: "Estimate the largest possible area of opening that seems to be required, and then multiply by two." Another, in more scientific form, but perhaps no greater practical value, is: Area of opening in sq. ft. $= c \sqrt{}$ drainage area in acres, c being a coefficient which varies with the topography. The author of the formula, Maj. E. D. T. Meyers, recommends $c = 1.0$ as a minimum in flat country, 1.6 in hilly, compact ground and 4.0 as a maximum in mountainous, rocky country. If any reader knows of other or better guides than these we shall be glad to hear from him.

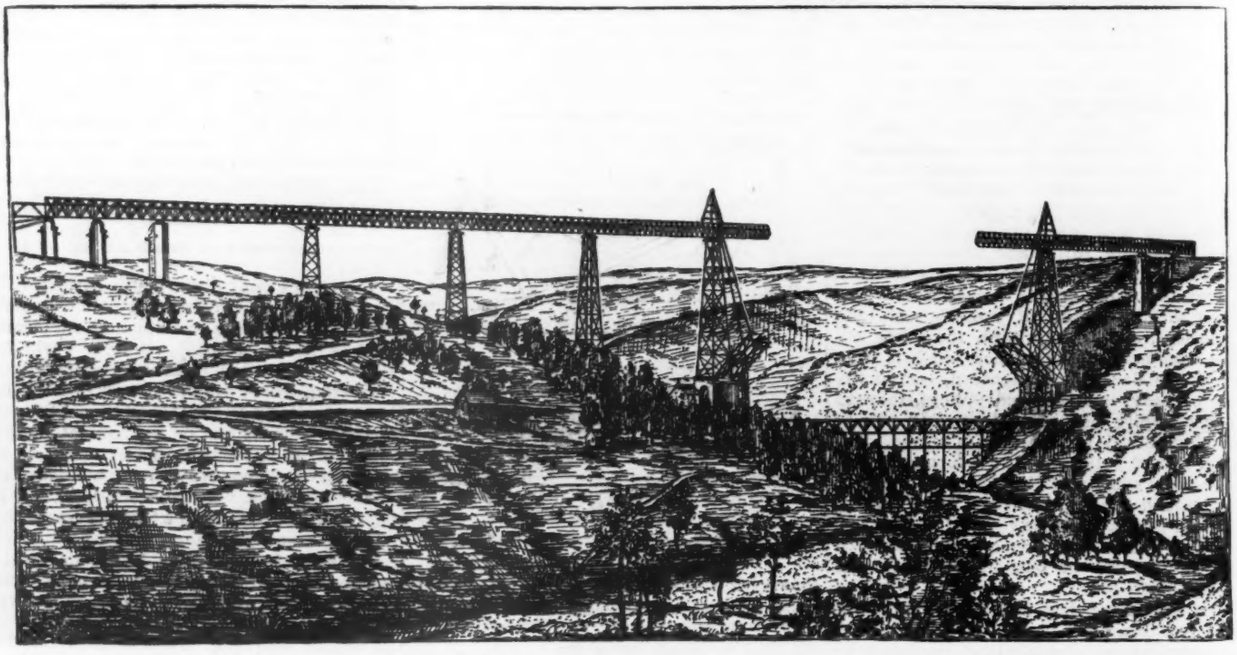
The Garabit Viaduct.

TRANSLATED FOR ENGINEERING NEWS FROM *Les Annales des Travaux Publics.*

The Garabit Viaduct is situated upon the railway connecting Marvejols with Neussargues (France). It crosses the deep valley of the Truyére, the height from rail to surface of water being 402 ft., and the width of the valley is 1,804 ft. M. Eiffel is the engineer of this structure, having previously designed and erected the Douro bridge in Portugal.

The general design is as follows: Main piers, 583 ft. (177.72 m) between centers; arch, 541.2 ft. (165 m) span at spring, 213.2 ft. (65 m) mean rise; in the remaining length of the viaduct are included 5 spans of rectangular truss bridge, each span 182 ft. (55.50 m) long.

In solving the problem of spanning a valley, deeper by 130 ft. than any crossed by a similar



THE GARABIT VIADUCT.—Fig. 1.

structure, the methods adopted had the advantage of offering no entirely novel or untried plans; on the contrary the work was accomplished by a combination of methods each of which had already received the sanction of experience.

Practically the plans adopted were those previously applied at the Douro bridge, but many improvements were made in the study of the present structure. Among the changes in detail was the substitution of a "U" section for the four posts of the main piers, with the fourth side latticed, instead of the solid box-section used at Douro, and a much more rigid lateral bracing in these new piers.

A parabola of the second degree was adopted for the base or medial line of the arch, and by the flatness of this curve at the crown of the arch, the continuity of the horizontal upper truss system was broken in such manner as to counteract the tendency to central flexure in the otherwise continuous girder. The center of the truss and the key of the arch practically form one solid member, an arrangement which gives the arch great stiffness; it may be compared to a trussed-girder forming a key, braced by two almost rectilinear struts, each portion in itself susceptible to very slight deformation.

The total length of the viaduct is (522.77 m) 1614.68 ft.

The total length of iron portion is (448.30 m) 1470.42 ft.

The horizontal truss is single cancellation,

in form a simple St. Andrew's cross; it is 16.92 ft. (5.16 m) deep. The roadway is placed 5.44 ft. below the top of the upper chord, and the floor system is a solid platform, impenetrable to a locomotive, and making a very stiff horizontal brace throughout the whole structure.

The piers, nearest to the arch, are in six stages, they are 200.6 ft. (61.16 m) high, exclusive of the masonry. Across the bridge these piers are 49.2 ft. (15 m) wide at the bottom, and 16.4 ft. (5 m) at the top; in line with the bridge they are 22.9 ft. (7 m) wide at base and 7.64 ft. (2.33 m) at the top.

The arch is 541.2 ft. span at the springing line, and the rise, to the intrados, is 196.8 ft. The key is 32.8 ft. deep, and the arch itself is made up of two trusses, which are 65.6 ft. apart at the spring and only 20.5 ft. apart at the

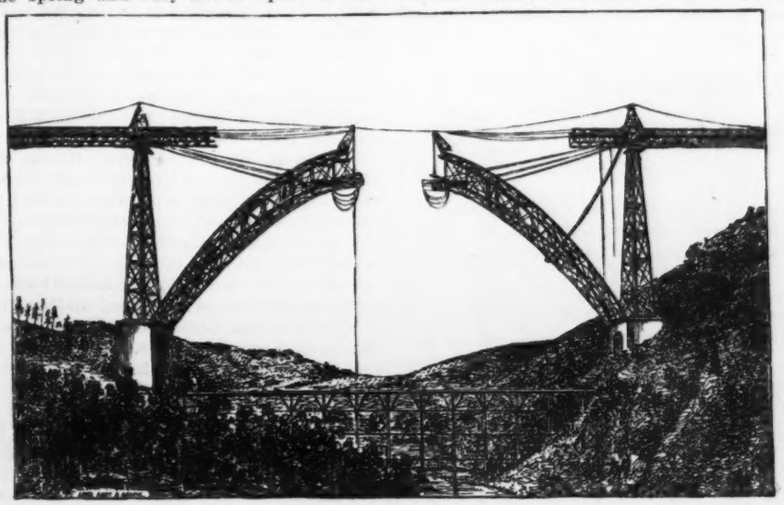


FIG. 2.

crown, measured on the extrados; they are hinged at the springing line.

All stresses were calculated at $3\frac{8}{10}$ tons to the square inch (6 kilos' to the sq. millimeter) under the combined effect of load and wind pressure. This last was assumed at 30½ lbs. to the sq. ft. (150 kilos, per sq. meter) during the circulation of trains, and at $55\frac{7}{10}$ lbs. per sq. ft. (270 kilos, per sq. meter) without train. The slight action of temperature was not added to the wind stress.

In calculating the strains upon the arch the method of graphical statics was made use of by M. Eiffel, and in comparing the separate effects of the permanent and live load and the wind pressure, he arrived at some rather remarkable results. These results may be practically summarized as follows:

Stress under permanent load.....	1.27	tons per sq. in.
" " live load only.....	1.27	" " " "
" " wind pressure only...	1.27	" " " "

In the arch bracing, the effect of loads are given at about:

Stress from permanent load.....	0.63	tons per sq.in.
" " live load only.....	0.63	" " " "
" " wind pressure only....	1.90	" " " "

The total weight of material in the structure is estimated at 7,054,720 lbs. (3,200 *tonnes*). The total cost, including all masonry, is put down at $620,000 (3,100,000 frs.); this would amount to about $341.16 per lineal ft. of viaduct (5,595 frs. per meter).

The Erection of the Arch. When the erection proper commenced, the arch and the viaduct was in the condition shown on Fig. 1. The iron piers were completely finished and the two upper trusses projected over the piers as in the illustration; each of the horizontal trusses was firmly anchored to the abutment masonry by 28 steel cables.

The arch-panels nearest to the piers were first erected by false works, and then suspended from the upper trusses by wire cables. The remainig panels were then built out, rom both sides simultaneously, and as the work progressed the first series of cables was replaced by three other systems, each in turn approaching nearer to the key. Care was taken to divide the load among the systems so that no one system was called upon to support the entire weight.

Although the length of each cable was carefully calculated, no dependence was put upon these measurements, owing to the elasticity of the cable and the fact that even a very slight variation in length would seriously interfere with the proper distribution of the load. Each cable terminated above in a screw provided with a special manometer, so that the direct tension in *kilogrammes* was actually measured at all times; the stress was equalized by the manipulation of the wedges under the head of each screw.

All the cables were made of steel wires, with a core of hemp. Each cable was made up of eight strands of nineteen wires each; each wire was .093 in. in diameter (2 mm, 40). The diameter of the cable was 1.69 in. (43 mm) and its weight was about 4½ lbs. per lin. ft. The maximum working load on any one cable was 33,000 lbs. (15,000 kilos.) while the breaking strain of each exceeded 176,900 lbs. (80,000 kilos.)

A temporary trestle bridge, (shown fn Fig. 2) spanned the ravine, and a track upon this brought the arch-member under the place which it was to occupy in the arch. Sheers resting on the completed portion of the arch were used in hoisting these pieces into place. Swinging platforms insured the safety of the workmen while riveting.

To facilitate the shifting of the sheers and to raise the transverse members, two small cars were used, which ran upon a cable suspended between two wooden towers just over the main piers. These towers were about 30 ft. high, and the lowest point in the curve of the cable was about 13 ft. above the crown of the arch. To move the cars and hoist material, a system of cables were employed which ran over sheaves placed in the overhanging trusses.

The instrumental work at the arch and the shop labor upon the arch-members was so carefully attended to, that no difficulty whatever was experienced in keying in the arch. No alteration of any kind was required.

This really remarkable result reflects much credit upon the State Engineers, under whose direction the arch was erected, and upon M. Eiffel the designing engineer.

The erection was commenced in July, 1883, and finished April 26, 1884. The weight of metal in the arch is 2,640,000 lbs.

Mr. R. L. Taylor, secretary for three years to the Chief Engineer of the Georgia Pacific R. R. has been appointed secretary to the President of the road.

Blue Prints.

The following is the general description of the blue process of copying drawings, taken from the second series of Spon's "Workshop Receipts":

"Cyanotype, or ferro-prussiate paper, is prepared by covering one side of the sheet with a mixture of red prussiate of potash (ferrocyanide of potassium) and peroxide of iron. Under the influence of light—*i. e.*, under the white portions of the drawing to be copied—the ferric compound is reduced to the state of a ferrous salt, which gives, with the red prussiate of potash, an intense blue coloration analagous to Prussian blue. This coloration is not produced in the portions of the sensitive paper protected from the light by the black lines of the drawing to be copied, and on washing the print the design appears in white lines on a blue ground. The formula for preparing the sensitive paper is as follow: Dissolve 10 dr. red prussiate of potash (ferrocyanide) in 4 oz. water; dissolve separately 15 dr. ammoniocitrate of iron in 4 oz. water; filter the two solutions through ordinary filtering paper, and mix. Filter again into a large float dish, and each sheet of paper to be sensitized for two minutes on the surface of the liquid, without allowing any of this to run over the back of the paper. Hang up the sheets in a dark place to dry, and keep from light and dampness until used. They will retain sensitiveness for a long time. The paper being ready, the copy is easily made. Procure either a heavy sheet of plate glass or a photographer's printing frame, and lay the drawing to be copied with the face against the glass; on the back of the drawing lay the prepared side of the sensitive paper, place upon it a piece of thick felt, and replace the cover of the printing frame, or in some other way press the felt and papers firmly against the glass. Expose, glass side up, to sunshine or diffused daylight for a time, varying, with the intensity of the light and the thickness of the paper bearing the original drawing, from minutes to hours. It is better to give too much than too little exposure, as the color of a dark impression can be reduced by long washing, while a feeble print is irremediably spoiled. By leaving a bit of the sensitive paper projecting from under the glass, the progress of the coloration can be observed.

"When the exposure has continued long enough the frame is opened, and the sensitive sheet is withdrawn and thrown into a pan of water, to be replaced immediately by another, if several copies are desired, so that the exposure of the second may be in progress while the first is being washed and fixed. The water dissolves out the excess of the reagents used in the preparation of the paper, and after several washings with fresh water the print loses its sensitiveness and becomes permanent. It is advantageous, after several washings with water, to pass over the wet surface a weak solution of chloride or of hydrochloric acid, 3 or 4 parts acid to 100 of water, which gives brilliancy and solidity to the blue tint, and prevents it from being washed out by long soaking. This should be followed by two or three rinsings with fresh water, and the print may then be hung up to dry, or placed between sheets of blotting paper.

"This mode of reproduction, the simplicity of which has led to its adoption in many offices, has the inconvenience of giving a copy in white lines on blue ground, which fatigues the eye in some cases, while the application of other colors is impracticable. By repeating and reversing the process, copying the white-line print first obtained on another sensitive sheet, a positive picture representing the black lines of the original by blue lines on white ground can be obtained; or the same result may be reached by a different mode of treating the sensitive paper. This latter may also be made by brushing it over with a solution of ferric oxalate (10 gr. to the oz.); the ferric oxalate is prepared by saturating a hot aqueous solution of oxalic acid with ferric oxide. A better sensitizing solution may be made by mixing 437 gr. ammonium oxalate, 486 gr. oxalic acid, and 6 oz. water, heating to boiling point, and stirring in as much hydrated peroxide of iron as it will dissolve."

From the above account our correspondent has no doubt derived the information that the printing frame is simply a convenient arrangement for holding the drawing against the prepared paper during the time it is exposed to the light. In its construction and management the printing frame used in this process of reproducing drawings is very much like the printing frame used by the photographer in printing photographs after the negative has been taken. In fact, the general process resembles the photographing as commonly practiced. In place of the usual negative, however, a drawing on paper more or less transparent is required. For this cloth-tracing from the original drawing is very commonly employed.

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Make all drafts, cheques and money orders payable to **Engineering News Publishing Co.**

We reprint in this issue the report of the Board of Experts upon the street paving of Philadelphia. It is an important document, both from the professional standing of the gentlemen composing the board and from the thorough manner in which they have performed their duty. Gen. Gillmore is too well known to need further mention; Capt. F. V. Greene, U. S. A., is the Engineer officer in charge of streets and roads of Washington, D. C., and Mr. E. P. North, M. Am. Soc. C. E., is an acknowledged expert, and some time ago received the Norman medal from the American Society of Civil Engineers for his paper upon the "Construction and Maintenance of Roads." The report can therefore be taken as a concise and authoritative statement of the best modern practice in street paving.

The replacing of old-time and inefficient street paving by systems more in accord with the demands of modern practice and increased traffic, is a problem to be solved by other cities than Philadelphia, and they are all correspondingly interested in the discussion of the subject. The longer this question is left unsettled the greater and more costly the change when it comes, as come it must. This is the case in Philadelphia, and a complete remodeling of its highways is estimated to cost about $21,000,000. This is an immense sum of money, but business, health and general comfort demand something better than the cobblestones which satisfied the generation past.

London Sewage.

Sir Joseph Bazalgette estimates that 23,000,000 cu. ft. of liquid sewage is daily poured into the Thames, containing 400 tons of solids. The mean progress of the sewage *down* river is only half a mile per day, and the Royal Commission say that it takes thirty days to reach the sea. The quantity of undiluted sewage discharged per day is sufficient to occupy a length of 750 ft. of the bed of the Thames at low tide.

Levelling a Chimney by Explosives.

In June, 1883, Lieut. Wiber destroyed the chimney of a sugar refinery in Aszod, near Budapest (Hungary), as follows:

The chimney is 196 ft. high, octagon in shape, diameter above base, 16 ft., thickness of masonry, 5½ ft., diameter at top 5 ft. 8 in. It was necessary to throw the chimney in a certain direction. A wedge-shaped piece; 3.28 ft. base and about 8 ft deep, was blasted out in sections just above the base of the chimney, on the side towards which the chimney was to fall. The blasting was done by first removing the right and left sections and then the center; five blasts, by electricity, were fired. Then 15 holes were drilled on the sides, from 0.65 to 1 ft., and in the middle 1.6 ft. deep; 10.15 lbs. of dynamite No. 1 were used. The success was complete.

Railway Gauges in America.

London, *Engineering*, in answer to a correspondents query, suggests the collating of the various railway gauges used in different parts of the world.

In this connection we give a summary of railway gauges as obtained from the reports of over 500 American, Canadian and Mexican railways. We do not guarantee the mileage figures, as it is a very difficult matter to pick this out with any degree of accuracy, but we believe it to be generally correct.

Standard Gauge	Roads or Systems	Total mileage.
6 ft. 0 in.	2	38
5 ft. 6 in.	2	76
5 ft. 3 in.	1	3
5 ft. 2 in.	1	8
5 ft.	47	11,478
4 ft. 9½ in.	1	37½
4 ft. 9 in.	35	11,631
4 ft. 8¾ in.	8	1,220
4 ft. 8½ in.	309	95,649
4 ft. 3 in.	3	75
4 ft. 1 in.	1	5
3 ft. 6 in.	9	514
3 ft. 4 in.	1	9
3 ft. 2 in.	1	48
3 ft.	108	8,672
2 ft.	2	34

This exhibit is somewhat startling to those who have not investigated the subject, and is proof sufficient that as yet the railway gauges of this continent are far from being "uniform." Leaving out of the question the exceptionally broad-gauges, which are few in number and mainly caused by local requirements such as the Mt. Washington Railway, the ruling broad gauge is 5 ft. and is principally confined to the Southern States. The next gauge of importance is the "compromise" or 4 ft. 9 in., the standard adopted by the Pennsylvania R. R. Co., and the numerous branches and feeders of this powerful corporation. The same gauge is also used by a number of roads centering at Cincinnati, Ohio.

The 4 ft. 8½ in. gauge is the rule for about 80 % of the mileage examined, and is found everywhere. The 3 ft. gauge is also widely scattered through the country, but if we take away the Denver & Rio Grande R. R. systems, 1665 miles, and three others averaging about 780 miles each, the average length for the remaining 104 roads is 45 miles each showing them to be generally short local roads.

The broadest gauge used in the U. S. is 6 ft. upon the Mt. Stirling R. R. in the State of New York, and upon a portion of the Tioga R. R. in Pennsylvania. The narrowest gauge of which we have any record, is 2 ft., upon the Sandy River R. R., of Phillips, Maine, and the Bridgton & Saco River R. R., in the same State.

The consolidation of a number of lines into one vast corporation, has had the effect of generally reducing to a uniform system the track-gauge under their control. As an example of what this consolidation means, we give the length of lines managed by some of the principal corporations.

Atchison, Topeka & Santa Fé	2,620 miles.
Baltimore & Ohio	1,612 "
Canadian Pacific	1,742 "
Central Pacific	4,303 "
Chicago, Burlington & Quincy	3,608 miles.
Chicago, Milwaukee & St. Paul	5,201 "
Chicago & Northwestern R'y	3,761 "
Denver & Rio Grande	1,665 "
Grand Trunk	2,332 "
Illinois Central	1,928 "
Lake Shore & Michigan	1,340 "
Louisville & Nashville	2,186 "
Michigan Central	1,485 "
Missouri Pacific and leased lines	6,029 "
New York Central & Hudson River	983 "
N. Y. Lake Erie & Western	1,973 "
Northern Pacific	2,207 "
Pennsylvania Co's Roads	3,222 "
Pennsylvania R. R. Co's Roads	3,158 "
Philadelphia & Reading & Branches	1,582 "
Richmond & Danville, R. R. Co's Roads	1,736 "
St. Paul, Minneapolis & Manitoba	1,402 "
Union Pacific	4,633 "
Wabash, St. Louis & Pacific	3,241 "

Life and Health.

London *Engineering* editorially discusses the influence of artificial light upon health, from the standpoint of the relative amount of air vitiated by the consumption of oxygen.

From the tables of Dr. Tidy, cited by *Engineering*, we learn, that, if burned to give a light equal to that of twelve sperm candles, burning 120 grains an hour, cannel coal gas, such as is used in Glasgow, would vitiate 217 cubic feet of air each hour; common gas, 348; sperm oil, 357; benzole oil, 376; paraffine oil, 484; camphene, 510; sperm candles, 615; wax candles, 632; stearine candles, 669; tallow candles, 933. Taking common gas, which stands high in the list, we can appreciate the actual danger resulting from the lack of proper ventilation in our homes and especially in places of amusement, where the light is brilliant and the crowd of human beings dense. It has been proven that there is twice as much carbonic acid gas, the dangerous element, in the Haymarket Theatre, London, at 11:30 P. M. as in the streets outside; four times as much in the underground railway as in the open air; and in an average mine the quantity of this gas exceeds by twenty times that above ground. The smoke and soot from inferior candles and lamps, and from gas itself is another evil loading the air we breathe with deleterious particles. Dr. Griffin, of Bristol states that 60 burners will produce at least 2 gallons of water per hour, to be scattered as steam, to the injury of delicate goods.

It is the sulphur always present in coal gas, according to another authority, that rots the leather binding of books, and discolors cloth and rusts metals, this sulphur passing into the air as oil of vitriol. For this reason among others, the electric light has been lately introduced into the British Museum. As an interesting and convincing instance of this destruction of books, Dr. Letheby mentions a case in which a book was recovered by a library after it has been lost for 36 years, and finally came back sound and strong, while the leather binding of its mates, standing on the library shelves, had given away.

Engineering draws the moral from this exhibit that electricity is the only, or by far the most healthful light, and while its expense as yet is a drawback, it should be adopted whenever possible. In illuminating power and cleanliness it is as much ahead of gas as was the gas-jet an improvement upon the oil-lamp of more ancient times.

Dynamite vs. Blackpowder.

The following record, from *Dingler's Journal*, Vol. 246, 1882, is interesting as showing the complete victory, in Europe, of dynamite over black or common gunpowder. The table records, in round numbers, the consumption of the two powders at the mines of Bleiberg, in Austria, during the years named:

Year.	*Blackpowder.*	*Dynamite No. 1.*
1872	63,500 lbs.	110 lbs.
1873	60,700 "	718 "
1874	66,400 "	771 "
1875	56,100 "	4,740 "
1876	53,100 "	12,090 "
1877	45,000 "	30,600 "
1878	10,500 "	54,000 "
1879	0	56,500 "
1880	0	68,000 "
1881	0	79,300 "

PERSONAL.

H. P. FEISTER, C. E., now in Paris superintending the erection of one of the Perfecting Printing presses lately patented by him, has been elected an Honorary Member of the French Society of Civil Engineers.

Pittsburgh Bridges.

With the completion of the Seventh street bridge, Pittsburgh will be one of the most notable points in the world for the examination of bridge architecture. The old stone structure, involving the heavy arch and the keystone, one of the earliest forms of stone construction known, is not represented here, but all modern ideas in bridge building are most beautifully exemplified. This city will shortly become a resort for those requiring instruction in bridge forms, and it is a source of honest pride that we already have such a diversity of the very best designs known to modern engineering. The Point Bridge has but one other like it in the world, and that is in Austria. It is a combination of steel and iron that forty years ago would be recognized as one of the wonders of the world. The new Smithfield street bridge is also a magnificent work of metalli architecture, and the Sixth street wire bridge is, without exception, the "prettiest" structure of the kind on the continent. In the sweeps of its cables, its minaretted towers, and the curve of each span there is something so pleasing to the eye that the bridge fastens itself on the memory of all who cross it. Singular as it may seem, the most noticeable bridge of the entire number is one that attracts the least attention. As "art work in timber" the Ninth street bridge is a curiosity. It is so braced, tennented and keyed that it is an exceptional piece of mechanical ingenuity. The railroad bridges also, crossing both rivers, are worthy the careful study of engineers. There are few cities in the world where mechanical effects can be studied with more satisfactory results than in Pittsburgh.—*Chronicle—Telegraph.*

LITERATURE.

The Materials of Engineering. In Three parts. Part III. Non-Ferreous Metals and Alloys: Copper, Tin, Zinc, etc.; Brases, Bronze, etc. By ROBERT H. THURSTON, A. M., C. E., Professor of Engineering Stevens Institute of Technology; Past President American Society of Mechanical Engineer; Member of American Society of Civil Engineers, etc., etc. New York, JOHN WILEY & SONS, Publishers. Price $4.

This the third and final part of Prof. Thurston's valuable contribution to engineering literature. As Part II was devoted to the investigation of iron and steel, this completes the list of the metals, used in construction, by a detail of the composition, properties and use of the non-ferreous metals and their alloys.

The author commences with the more common and useful metals, as zinc, copper and tin, and enters exhaustively into their mining, reduction, and application to the arts. The brasses and other copper-zinc alloys follow. The investigation into the strength of these metals and their compounds is most thorough, and the various tables given are mainly the results of personal experiment by the author, who has made the behavior of the non-ferreous metal alloys under stress of all kinds a careful and special study.

One of the very interesting chapters in this work is that devoted to the conditions effecting the strength of the metals investigated, and that of their alloys. The modifications brought about by reason of the application of heat, and the sudden variation of temperature, the effect of tempering and annealing and the effect of prolonged strain and variable stress, are treated upon fully and plainly.

The closing chapter is devoted to the mechanical treatment of metals, and describes the Whitworth process of compressing the molten metal, rolling, hydraulic and drop forging, etc. The Dean method of cold working bronze, now known as the Uchatius method, is explained, and the credit for this discovery relegated to its proper source.

The subject matter throughout is handled in the intelligent and conscientious manner characteristic of its author, and it will be doubtless received as a standard authority by those interested in the composition, treatment and application of the non-ferreous metals and their alloys.

The Modern High Explosives, Nitro-Glycerine and Dynamite: Their manufacture, their use and their application to Mining and Military Engineering; Pyroxyline, or Gun-Cotton; the Fulminates, Picrates and Chlorates. Also the Chemistry and Analysis of the Elementary Bodies which enter into the Manufacture of the Principal Nitro Compounds. By MANUAL EISSLER, Mining Engineer. New York. JOHN WILEY & SONS, publishers. Price $4.

The author of the above treatise has produced a useful book upon a subject comparatively little known but of great and growing importance. Commencing with the chemistry and analysis of his subject, he passes to its practical application and has illustrated this portion of the work by a number of examples taken from modern practice.

The practical portion of the subject matter relates to the preparation and handling of the explosives and to the most effective manner of using them under a variety of conditions. Included in this part is a chapter upon the principles of blasting. An interesting and useful section is devoted to the application of high explosives to the cutting of trees, removal of stumps, rocks, etc., clearing of ice-bound streams, and breaking up of submarine obstructions.

Very properly, as we view it, Mr. Eissler has left the application of these explosives to military purposes as the subject for a separate work, and has only treated of them in their industrial phase.

Taken as a whole the book is valuable to a large class of consumers, interested in the history, composition and application of one of the great factors in modern progress, which has made possible feats of human enterprise that would have lacked the means of execution less than a generation ago.

CORRESPONDENCE.

Corrosion of Cast-Iron Pipes.

Special Correspondence Engineering News.

NEWPORT, KY., Aug 4, 1884.

EDITOR ENGINEERING NEWS:—Referring to Mr. McElroy's article in your issue of Aug. 2d, we are glad to note that he is now willing to allow the past six years as a period during which the methods of casting iron pipe may have improved, although in his original remarks he allowed no "benefit of doubt" accorded to what he called recent practice. Not caring to advertise ourselves particularly in this connection we will say for the general benefit of the Cast-Iron-pipe trade that at the Warren Foundry, Phillipsburg, New Jersey, about an hours ride from New York, Mr. McElroy will find in full practice, the methods of casting iron pipe which are now in vogue with all first-class shops in the country, and we have no doubt the proprietor of that establishment will take pleasure in showing him the system of casting and such other details as he may need. In our own practice the number of contracts filed in the past few years have been many, and extending from points in New York State to Omaha, Nebraska. The specifications upon which they were based have been those of J. D. Cook of Toledo, O., Mr. Birkinbine of Philadelphia, and others, in which the requirements were the same. No doubt, Mr. McElroy can procure copies from either of the engineers named, or he can find the same general specifications in the office of Water-Works Department of the city of New York.

In these contracts as filled by us, there have been no pipe rejected, except a piece occasionally for causes obvious at once upon being taken from the mould, being imperfections in structure that might apply to any casting and not caused by any deficiency in method of casting, nor preventable by any known improvements or changes therein.

The requirements of tensile strength are 16,000 pounds to the square inch, which in actual practice is exceeded in almost any foundry by from 10 to 25 per cent. The tensile strength of the "pig" is not sought for except as it is indicated by test bars, cast from a mixture of several kinds of "pig," which shows what may be expected of the pipe itself. No analyses of metal as it exists in the pipe are obtained that we know of. We have analyses by our own chemist of all the brands of "pig" we use, and will gladly show them to Mr. McElroy if he ever comes this way, but having accumulated them at some expense we do not care to make them public property.

If such information as is easily obtainable within a short ride of Mr. McElroy's office is not sufficient to post him thoroughly on both the requirements of Engineers and the manner in which they are met by pipe founders, we will try again to furnish him with what is necessary. It is his main idea as to the process that we desire to correct, and if not yet accomplished he can easily do it himself by a little personal investigation.

Yours truly.

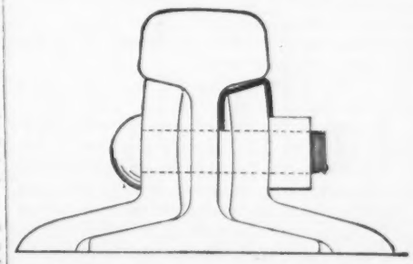
CINCINNATI & NEWPORT IRON & PIPE CO.

The Clement's Nut Lock.

Special Correspondence Engineering News.

THE MISSOURI PACIFIC RAILWAY COMPANY,
ST. LOUIS, MO., July. 25, 1884.

EDITOR ENGINEERING NEWS:—I enclose to you herewith a sketch of an invention which I think will supply the railroads of this country with something they have been needing for a long time, viz., an effective nut lock. The application of the nut lock is shown clearly, I think, in the accompanying plan. The first step is to cut a slot in the fish bar or angle plate where its top meets the ball of the rail, and at a point flush with the right hand side of the punching for the bolt. Then take our nut lock, which is nothing more or less than a little piece of iron two inches long by one half of an inch wide and one sixteenth of an inch thick, place it in



the slot, and drive it home, i. e. until it's point reaches the top of the bolt in the space which is always found between any kind of splice and the rail. Then bend over the nut lock to a bearing on the nut and it is almost impossible to move the nut. To do so it would be necessary to overcome the crushing resistance of the piece of metal. The cost of cutting these slots and also of manufacturing the locks is very trifling, only seven dollars per mile, against a cost of nearly thirty dollars for the cheapest nut lock now in use, and it is a well established fact that no lock now on the market will effectually lock the nut. Thinking your numerous readers would be interested in anything of this kind, I have sent the enclosed for insertion in your columns.

Yours Respectfully,

J. B. CLEMENT.
Assistant Engineer.

The Cost of Dredging.

Special Correspondence Engineering News.

WILMINGTON, DEL., Aug. 4, 1884.

EDITOR ENGINEERING NEWS:—As a contractor for dredging and dredging appliances of thirty years' experience, I have read with much interest the articles published on pages 51 and 52 of No. 5 of your journal. In the main the writer evinces considerable knowledge on the subject and many of his estimates are quite correct. He is evidently not a practical dredging man or contractor familiar with details of cost, etc. No allowances are made for loss of time by reason of enforced idleness, caused by winter months, unfavorable weather while on work, transportation between points, costs and risks of the same, etc.

By reference to the Annual Reports of the Chief of Engineers, U. S. A., it will be seen that dredging has been done for several years past under contract at extremely low rates. In harbors and their approaches at from 7c. to 15c. per cubic yd. and the material removed from three to twelve miles from place of excavation, the cost of removal after dredging is frequently greater than that of excavation. The large profits "handsome and often quite enormous," have not been realized by any company or individual within the writer's knowledge engaged in contracting for dredging during the past ten years.

Very respectfully,

F. B. COLTON.

TURNOUTS:

Exact Formulæ for their Determination, together with Practical and Accurate Tables for Direct use in the Field.*

BY W. B. PARSONS, JR., C. E., ROADMASTER NEW YORK AND GREENWOOD LAKE DIVISION, ERIE RAILWAY.

(Continued from page 56.)

THREE-THROW SWITCHES.

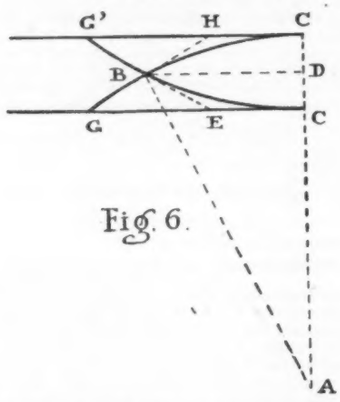


Fig. 6.

1st Case.—When Frogs are of same angle.

A three-throw switch is a turnout to both right and left. Let the main-track be as shown in Fig. 6, with a turnout to both right and left; the outer rails $G\,C$ and $G'\,C'$ intersect at B and are tangent to main-track rails at C and C', so that both turnouts have their heels on the same perpendicular $A\,C$.

Since the frogs G and G' have the same angle the distances $G'\,C$ and $G\,C'$ are equal, and therefore the frogs are opposite each other. Each turnout follows the laws upon which formulæ 1 to 3 are based, and are worked out in Table No. 1. It therefore only remains to find the distances from point of crotch-frog at B, where the turnout-rails intersect, to either the heel of the switch or the head-block, and the crotch-frog angle.

Let R denote radius of turnout, then $A\,D = R = A\,C - \frac{1}{2}\,g$, and $A\,B = R + \frac{1}{2}\,g$.

In the triangle $A\,B\,D$

$$B\,D = \sqrt{A\,B^2 - A\,D^2} = \sqrt{g\,(R + \tfrac{1}{4}\,g)} \qquad (14)$$

which gives the distance from heel of switch to point of crotch frog.

The distance from head-block to point of crotch frog equals $B\,D$ — length of moving-rail. (15)

The angle of the crotch frog is $E\,B\,H$, and one half the angle is $H\,B\,D = \frac{1}{2}\,F'$

$$\text{Sin. } A\,B\,D = \frac{A\,D}{A\,B} = \frac{R}{R + \frac{1}{2}\,g.};$$

but

$$H\,B\,D = 90^\circ - A\,B\,D = \tfrac{1}{2}\,F';$$

whence

$$F' = 2\,(90^\circ - A\,B\,D) = 2\left(90^\circ - \sin.^{-1}\frac{R}{R + \frac{1}{2}\,g.}\right)$$

$$= 2\cos.^{-1}\frac{R}{R + \frac{1}{2}\,g.} \qquad (16)$$

that is, the crotch frog angle equals twice the angle whose cosine is $\dfrac{R}{R + \frac{1}{2}\,g.}$

The results deduced from equations 15 and 16 for the various frogs from No. 6 to No. 13 are given in columns 9, 10 and 11 of Table No. 1. These results are practically the same whether the main track is curved or straight.

CORRECTION.—Formula 12, in our issue of August 2, should read as follows:

$$A\,B = d - \frac{g}{\dfrac{\text{cos. } F}{\text{tan. } F}} = \frac{d\cos. F - g}{\text{sin. } F}$$

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2nd Case.—When Frogs are of Different Angles.

As in the first case the two turnouts have their heels in the same line $A\,D$, but, since the frogs have different angles, the frog distances $G\,C'$ and $G'\,C$ are also different, and the frogs G and G' are no longer opposite. The crotch frog B is also no longer in the center of the main track. It is therefore necessary to know $C\,E$, or the distance the point is from the main-rail $C\,G'$ also $B\,E$ and the crotch frog angle.

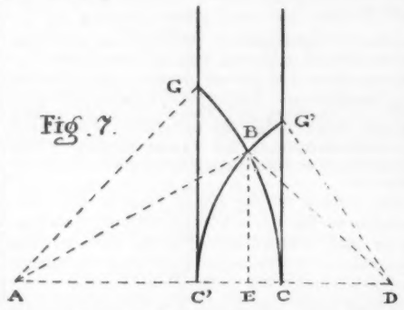

Fig. 7.

In the triangle $B\,A\,D$, (Fig. 7) we know the three sides,

$A\,B$ = Radius of turnout of the left frog $+ \frac{1}{4}\,g = R' + \frac{1}{2}\,g$; $B\,D$ = Radius of turnout of the right frog $+ \frac{1}{4}\,g = R'' + \frac{1}{2}\,g$; $A\,D$ = Sum of the two radii $= R' + R''$.

Then find the angle $B\,A\,D$,

whence, $B\,E'$ = sin. $B\,A\,D\,(R' + \frac{1}{2}\,g)$ (17)

This is the distance from heel of switch to the point of crotch frog.

$A\,E$ = cos. $B\,A\,D\,(R + \frac{1}{2}\,g)$;

but, $C\,E = A\,C - A\,E = R + \frac{1}{2}\,g -$ cos. $B\,A\,D\,(R + \frac{1}{2}\,g) = (R + \frac{1}{2}\,g)\,(1 -$ cos. $B\,A\,D.)$ (18)

This gives the distance between point of crotch frog and opposite rail.

To find the angle of the crotch frog, first find the angle $A\,B\,D$, then

Crotch frog angle $= 180^\circ - A\,B\,D.$ (19)

Table No. 4.—Ordinates.

Frog Number.	DISTANCE, IN FEET, FROM BLOCK. 10 ft.	20 ft.	30 ft.	40 ft.	50 ft.	60 ft.	70 ft.	80 ft.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
5½	3 9	2 8½	0 7½	0 5½	0 4⅝	0 3½	0 2¾	0 2⅛
6½	3 7⅞	2 6½	1 5½	0 4⅜	0 3⅝	0 2¾	0 2⅛	0 1⅝
6½	3 8½	2 8½	1 7½	1 0	0 4⅝	0 3½	0 2¾	0 2⅛
7½	3 9½	2 10¼	1 9½	1 2	0 5⅜	0 4⅛	0 3¼	0 2½
8½	3 10½	3 0¼	2 0½	1 3½	1 0	0 4⅝	0 3⅝	0 2⅞
9½	3 11½	3 2¼	2 2½	1 5	1 1⅛	0 5⅜	0 4⅛	0 3¼
10½	4 0½	3 4¼	2 4½	1 6½	1 2⅜	0 6⅛	0 4¾	0 3⅝
10½	4 1½	3 6¼	2 6½	1 8	1 3½	1 0	0 5⅜	0 4⅛
11½	4 2½	3 8¼	2 8½	1 9½	1 4⅝	1 1⅛	0 6⅛	0 4¾
12½	4 3½	3 10¼	2 10½	1 11	1 5¾	1 2⅜	0 7	0 5⅜
13	4 4½	3 11½	3 0½	2 0½	1 6⅞	1 3½	0 7⅞	0 6⅛

There is another case where instead of the heels being in the same line, some other points, as the head-blocks for instance, are in a line. The dimensions for such a combination can be most readily obtained from a carefully made scale drawing.

TO BE CONTINUED.

Tamping Drill Holes with Plaster of Paris.*

BY FRANK FIRMSTONE, EASTON, PA.

In the summer of 1881 we were forced to break up and remove the large mass of iron which had accumulated under No 2 furnace at Glendon, in order to prepare the foundations of the new furnace which has taken its place.

We used "Atlas" powder, drilling the holes with a pair of Rand drills. These worked very well when the iron was at all uniform in hardness; but this was not often the case; and it frequently happened that the holes were hopelessly blocked when but little over a foot deep. Good tamping became, therefore, very important.

Tamping in the ordinary way holes having percussion caps in them is very dangerous, and has, no doubt, caused many of the accidents attributed directly to high explosives. We found an excellent and safe method by using plaster of Paris, mixed to the proper consistency and poured into the holes as soon as they were loaded. Clean dry sand was mixed with the plaster to reduce the quantity needed.

With proper attention the tamping would set in a few minutes, and little or no more time was required than for tamping in the ordinary way.

We used a "magneto" machine (Laflin and Rand) to fire the holes; and an additional advantage in the plan was that any risk of cutting the exploder-wires in tamping was avoided.

We found it worth while to load holes not over 13 inches deep in a block 3 or 4 feet thick, since the bottom of the hole was enlarged by each shot so that the next time it could be loaded more heavily, and three or four shots in this way often did as much good as a new hole twice the depth, to drill which might have taken ten or twelve hours.

The rise in temperature when boiled plaster solidifies is often sufficient to ignite the exploders, as we found by repeated trials before using it in a loaded hole.

DISCUSSION

S. Whinery, Meridian, Miss.: During the summer of 1878, while engaged on the improvement of the Tennessee River at Muscle Shoals, Ala., under Major W. R. King, U. S. Engineers, I had occasion to blast a large amount of limestone rock from the channel of the river. The surface of this rock was from 1 to 3 feet below the surface of the water, and the drill holes were from 1 to 3 feet deep. The depth of water not being sufficent to make water-tamping entirely satisfactory, I experimented with several methods and substances for tamping under water. Among these, plaster of Paris was pretty thoroughly tried. When the charge of dynamite, with the platinum fuse, was in place at the bottom of the drill-hole, plaster of Paris, mixed quickly with sufficient water to make a rather thin mortar, was run into the drill-hole by means of a funnel and tin tube, the lower end of which was placed directly over the top of the drill hole. The charge was allowed to stand twenty to thirty minutes for the plaster to set, when it was fired in the usual way by a dynamo-machine. This tamping gave very satisfactory results; but it was found difficult to have the plaster used properly and intelligently by the class of laborers employed, and the plaster would adhere and harden on the inside of the tube so as to fill and obstruct it in a short time. The advantage gained by this close and hard tamping, over the water-tamping, was not found to be sufficient to justify its use under the disadvan-

* Read at the Cincinnati Meeting of the American Institute of Mining Engineers, February, 1884.

tages named above, and it was discontinued. Where several hundred holes were to be drilled, charged, and fired each day, in sets of from fifteen to twenty each, and any delay in charging and firing seriously delayed the whole work, the saving of time, when the charge was simply sunk to the bottom of the hole, the wires connected, and the charge fired, was more than enough to compensate for the defective water-tamping.

Dr. R. W. Raymond, N. Y. City: I would call attention in this connection to the fact that, although the rise in temperature in plaster of Paris be not sufficient to explode any of our highest explosives, there is an element of danger perhaps not peculiar to the use of this substance; and yet, in proportion as it is a perfect tamping, in that proportion this element of danger is present. It is not safe to leave any of the high explosives (at least those which are compounds of nitroglycerin,) after tamping for any considerable period of time in such a confined position. A rise in temperature, which may not be enough of itself to cause explosion within a reasonable period, is often enough to set a generation of gas going which will bring the pressure which *will* cause explosion, The thing to be done after tamping is to fire at once. My attention was called to this in the early days of the use of a nitroglycerine powder, on the Pacific coast. I think the case is mentioned in my first report (1869) as United States Mining Commissioner. As I recollect it, a hole had been tamped in the mine just about the time to go to dinner, and the men having gone to dinner leaving the hole with the exploder in it, but not lighted. It went off during their absence of itself, injuring nobody, but surprising them a good deal. They had the idea that dynamite was as safe as brown sugar; and among the miners the belief was that, in order to be safe, one had only to be careless with it, and leave it lying around loose. There was some truth in that maxim; but when you come to bottle it up, to pack it in a drill hole, and put tamping on top of it, then the elements of danger are present, and it is simply wise to fire it as soon as you can.

At the same mine, where I examined it with some curiosity, they had a box of cartridges, which they had brought and loaded at the mouth of the tunnel leading into the mine, into which the men went and fished out a cartridge as they wanted it. This box lay for some hours, the first day after its arrival, under the rays of a Californian sun. Well, all that happened was, that slowly the lid of that box rose right up. Without question there was a generation of gases going on at the comparatively low temperature caused inside a wooden box by the sun outside—a generation of gases—which lifted the lid and relieved the pressure, so that there was no explosion. But rigid tamping of a drill hole would make trouble I think if it should be abandoned too long.

William Kent, Jersey City, N. J.: I would suggest that, just before the tamping with plaster of Paris, some compressible substance be inserted, with the double object of preventing the conduction of heat and of making a compressible cushion, against which the gases could work, instead of confining them in a solid, close receptacle.

Dr. Raymond: I am inclined to think that that expedient would rather weaken the effect of the high explosive in particular cases, like the one cited in this paper, when it is designed to burst asunder salamanders of iron. In that case I suppose that any compressible substance making a cushion would enable the charge to lift more, and lose tearing power, because there would be a yielding at the instant of the first impulse, before it came to act directly upon the rigid inclosure. I have no doubt that such a cushion would have the desired effect where tearing was not so much required as lifting, assimilating the effect of the explosion to that of gunpowder. I have no doubt that a safety-pad would be effective in counteracting the dangerous results of the generation of gases, and perhaps even increasing the force of powder; but at the same time I doubt whether it would do as good work in actually shattering solid rock.

William Kent: The space occupied by the gases generated before the explosion is so small (being but a few cubic inches to several thousand times as much), compared with the whole volume of the gases after the explosion, that I think the effect in lessening the force of the explosion would be imperceptible.

W. S. Ayers, Allamuchy, N. J.: I have found in limestone that a cushion did affect the tearing power of the powder; that the explosion did not shatter the stone as thoroughly as it did when the cushion was not used.

The St. John Bridge.

The St. John (N. B.) *Telegraph*, of July 7, gives the following account of the new cantilever bridge over the St. John River at that city:

"The steel cantilever railway bridge across the river at the falls is now so far advanced that a description of the structure and the railway extension through Portland will be of interest. The bridge and approaches are being built by the St. John Bridge & Railway Extension Co. Hon. Thos. R. Jones is President, and takes a lively interest in the progress of this important enterprise. The Dominion Bridge Co., of Montreal, is the contractor for the erection and building of the bridge. Its representative here is Mr. F. E. Came; the foreman is Mr. M. H. Hasler. Mr. M. J. Hogan, of Quebec, has the contract for grading the extension and the masonry work of the main bridge as well as of the overhead bridges on the line through Portland. His interests are looked after by Mr. W. Marrigan. Exercising a general supervision over the entire work is Mr. P. S. Archibald, Chief Engineer of the Intercolonial Railway. His assistant is Mr. Gilmour Brown.

"As before stated, the bridge is of the steel cantilever principle, the weight of the span being supported by enormous masses of iron in the anchorages on either side. The western cantilever is 381 ft. 6 in. long, the eastern 286 ft. 2 in., the intermediate or connecting span being 143 ft. 1 in. At the anchorage of the western cantilever the height of the superstructure is 28 ft., the height of the truss over the pier being 80 ft. The center span is 28 ft. in height. The truss over the eastern pier is 64 ft. high, and the superstructure over the anchorage the same as on the western bank. Accommodation is only given for one track on the bridge, which is 20 ft. in width. The structure when completed will resemble the bridge recently built across the Niagara, with the exception that while the latter is a deck bridge, the one across the St. John is what is termed a through bridge—that is, the truss-work is above the track level instead of underneath as at Niagara. From low water mark the height of the structure is 94 ft. (8 in. higher than the present suspension bridge); high water 72 ft.

"Nothing but the best of material will enter into the construction of the bridge, which will be built entirely of German steel, some of the bolts being of wrought iron. In about two weeks the erection of the bridge itself will be commenced. The steel is rolled in Germany, England and Scotland, and delivered at Montreal, where it is now being manufactured into sections to be shipped to St. John as fast as required. The western cantilever will be shipped by Grand Trunk, Maine Central and New Brunswick Railway; the eastern cantilever by the Intercolonial. As the extension through Portland is not completed the western sections will be brought down and first placed in position. It is estimated that under the weight of a heavy freight train the central span will not deflect more than 2 in. The bridge will be held together by steel pin connections. The bridge will be painted with anti-corrosive paint, the compression members of dark red and the tension members of a lighter color.

"The piers are now finished. The western anchorage is about half completed, and excavations are now being rapidly pushed forward for the eastern anchorage. The foundations for the trestle on the west side of the bridge are completed, and work is now being rapidly projected on the trestle where the junction is made with the New Brunswick Railway track. This trestle will be of steel, 450 ft. in length, composed of 60 and 30 ft. spans. At the highest point it is 62 ft. from the ground. It is founded on stone pedestals. The scaffolding to the level of the trestle was commenced on Friday. The immense iron beams of the west end anchorage, which are to support the cantilever on that side, are now in position. Considerable blasting remains to be done before the eastern anchorage will be ready.

"Starting at low water line the foundations of the eastern pier have been blasted out of the solid rock, the dimensions on the bottom being 32 by 15 ft. It runs up 91 ft. with a batter of 2 in. in every 3 ft., the area on the top being 28 by 9 ft. The western pier is founded on the side of the cliff at a point about 35 ft. above high water mark, and also rests on solid rock. This pier rises to a height of 51 ft. to a level with the other pier, its area on top and bottom being the same, and the batter of course somewhat heavier. The piers are 477 ft. apart, which represents the clear span of the bridge. They are built of granite, quarried at Eagle Rock, which was brought down the New Brunswick Railway to the siding, near the asylum, and transported by teams to the sites of the piers where the immense blocks were lowered into place by very large derricks worked by horse-power. The stones are laid in regular courses of an average thickness of 2 ft., the best of English Portland cement mortar being employed. Some idea of the strength of the granite may be formed by the estimate of the Assistant Engineer, Mr. Brown, who states that the eastern pier could be built up to a height of about one mile in the air before the bottom stones would be crushed by the enormous weight.

"The extension through Portland is somewhat over a mile in length. Commencing at the Intercolonial wharf, York Point Slip, the road crosses Fisher's pond, the public slip, Long wharf, St. Helena wharf to Acadia street. There has been constructed 900 ft. of trestle work across these ponds, composed of 40 and 21 ft. spans. At Long wharf and St. Helena wharf piles 45 ft. long have been driven down through the wharves into the mud. These poles are capped with red pine timers and stringers. Acadia street is crossed at right angles, and from this point to the crossing of Straight Shore road, west of Chesley's foundry, extends an earthen embankment 43 ft. high at the highest point, and containing 80,000 cu. yds. of earth. Simonds street is crossed by a 25 ft. span overhead bridge of iron with stone abutments. This bridge has not yet been erected. An overhead bridge, span 40 ft., traverses the Hedyard crossing. It is also of iron with stone abutments, one of the abutments finished, the other in course of erection."

The Black Line Process of Copying Drawings.

We clip the following practical description of the black line process of copying drawings from a recent number of the *American Machinist*, in which it appeared over the signature of Mr. A. G. Brown, of the Westinghouse Machine Company, Pittsburg, Pa.

In regard to your inquiry about black line process, it is very elaborate as compared with blue printing, and requires considerable skill to get good results. Below is a practical description:

To print 36 plates, 24" × 36", would require—

2	gallons collodion,	@ $2.60,	$5.20
2	" sensitizer,	@ .20,	.40
1	" gelatine,	@ .80,	.80
24	" water,		
	Total,		$6.40

Any good, smooth, white paper, bond paper, tracing cloth or paper, or bristol board, may be used. (Egg shell or tinted paper are of no use.)

Clean a glass the size of drawing, float it with collodion, take it to a dark room and coat with sensitizer, using a soft brush; dry over a gas stove about two minutes. Place glass in a frame under drawing to be copied, and expose to bright sunlight from forty-five seconds to four minutes, according to opaqueness of negative. Remove it to dark room and dust the glass with lamp-black—the lamp-black will stick to the lines only—float again with thin collodion. Wet tracing cloth or paper (on which print is to be made) with water containing gelatine, and lay the wet paper (or cloth) on the glass, and rub down flat with a straight edge. Dry for about an hour, then peel it off the glass by starting at one corner. The print is perfectly waterproof, and can be mounted and washed.

When putting the negative on the sensitive plate place the ink lines next the plate. After cleaning glass thoroughly, rub it with powdered french chalk, and the collodion film will strip off easier.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E. : M. INST. C. E.

(Continued from page 59.)

DCLXV. HAMILTON, O.

Hamilton, Butler Co., Ohio, in lat. 39° 20′ N., long. 85° 45′ W., is on the Big Miami River.

In 1791, Fort Hamilton was established, five years later the town was laid out, and in 1816 it was incorporated a city.

Water-works were built by the city in 1883-4, after plans of J. D. Cook, C. E., taking the supply from ground water by an open basin excavated in saturated gravel. A cast-iron conduit, 30 in. in diameter and 300 ft. long, carries the water to the pumps whence it is pumped by a compound duplex pump of 22 and 46 in. steam, and 16 in. water cylinder and : in. stroke, made by the Gordon & Maxwell Co., to a reservoir, constructed in earth, holding 5,000,000 gallons, and having an elevation of 220 ft. above the average level of the city.

Distribution is by 24½ miles of cast-iron pipe of 20 to 4 in. in diameter with 188 fire hydrants and 248 gates. Service pipes are of lead and wrought iron. The population in 1880 was 12,122, it is now said to be 18,000.

The works having just been completed the number of taps cannot be stated. The cost of the works will not exceed $325,000. The works are managed by a board of trustees, of which Asa Shuler is President, and Ira S. Millikin, Secretary.

DCLXVI. GLOUCESTER CITY, N. J.

Gloucester City, Camden Co., New Jersey, in lat. 39° 53′ N., long. 75° 8′ W., is on generally low and sandy ground.

Settled in 1623 it was incorporated a city in 1868. Water-works were built in 1883-4 by the city, after plans of H. P. M. Birkinbine, C. E., the supply being taken from springs. It was intended to use the waters of Newton Creek, but in excavating for a settling reservoir springs were found which furnish a daily supply of 500,000 gallons. This reservoir is below the level of the city and is 178 ft. by 132 ft. on top and 122 ft. by 82 ft. at the bottom and 14 ft. deep, holding 2,000,000 gallons, and from it the water is pumped by two compound steam pumps made by Robert Wetherill and Co., lifting 100 ft. to a stand pipe 18 ft. in diameter and 75 ft. high. A fire pressure of 125 lbs. can be obtained by direct pumping.

Distribution is by 8 miles of cast-iron pipe of 20 to 4 in. diameter with 50 fire hydrants, 75 gates and 37 taps. Service pipes are of lead and galvanized iron.

The population in 1880 was 5,347.

The works have cost $85,200. The bonded debt is $80,000; $60,000 at 4 per cent., and $20,000 at 6 per cent. James Finley is Engineer of the works.

WATER.

TO THE ADVERTISERS IN CROES' STATISTICAL TABLES.—In accordance with our Contract with Advertisers in Croes' Statistical Tables we have mailed one or more copies of "Tables" to every Water-Works office in America of which we could gain any intelligence. We have sent them to every person whom we could associate in any way with Water-Works interests; we have distributed them among the officials of towns which are contemplating a water supply; our advertisers have distributed extra copies where they "would do the most good," and great care has been exercised in not allowing copies to be wasted. We have some copies still on hand to be sent to parties yet to be discovered. If any of the advertisers in the "Tables" know of *a single* Water Works office in America being unsupplied with a copy, or if they know where another copy can be placed to advantage, and will so inform us, we will mail one or more at once *free of cost*. We want *every copy* to be out and at work for our patrons and ourselves, and the sooner it is accomplished the better pleased we will be.

THERE are 418¾ miles of water-pipe in use in Chicago.

THE water used in Chicago is over 73,000,000 of gallons daily.

THE Memphis, Tenn., water company has had to caution consumers concerning the waste of water.

DAYTON, O., employs a watchman to guard the purity of Mad river, whence comes its water supply.

THE Sayre, Pa., Water Works will be completed in about thirty days.

MARSHALL, Mo., has let the contract for its water-works to George B. Inman of New York for $55,000.

THE system of Water Works of Council Bluffs, Iowa, cost $600,000.

THE main aqueduct supplying the City of Mexico has burst. Water is being carried to the city and is sold at fabulous prices.

A CORLISS engine, with a pumping capacity of 10,000,000 gallons every 24 hours, costing $45,000, has been set up for the Omaha Water-works.

JAMES MANCHESTER, Superintendent of LaCrosse Water-works will open proposals for building a well and conduit for that city to-day, the 9th.

PROPOSALS for the construction of the Parkersburg, W. Va. Water-works were opened on the 7th at the office of the Commissioners in Parkersburg. Mr. J. W. Hill of Cincinnati O., is Consulting Engineer.

THE rainfall in New York, during August 4 and 5, amounted to 2.18 and 1.52 inches respectively. The mean precipitation for the month of August for a number of years in this vicinity has been 4.62 inches, but this month we have had 3.70 inches in two days.

FAIRFIELD, Ia., is building a system of Water Works similar in all respects to those of Mt. Pleasant in the same State. From four to five miles of pipe are being laid. Cost $50,000 to $60,000. The contractors are the Inman Bros. of this city.

THE contract for extending the water system of Blue Island, Ill., has been awarded to McRitchie & Nichol, of Chicago. The work, which will include the laying of two and a half miles of pipe, and the placing of twenty-five hydrants, will be completed by Oct. 1.

PROF. LEEDS, of the Stevens Institute of Technology, has completed his analysis of the Hackensack water, concerning the impurity of which Hoboken residents have loudly complained. He ascribes it to the presence of decayed vegetable matter. The reservoir is now being cleaned.

THE city of Rockford, Illinois, has just ordered from the Holly Manufacturing Company of Lockport, N. Y., one of the Gaskill Horizontal, Compound, Condensing Pumping Engines, of 4,000,000 gallons daily capacity, for both domestic supply and fire protection. Duty guarantee 80,000,000 foot pounds, per 100 pounds of coal.

IT is expected that the new tunnel for the Hyde Park Water Works will be completed by August 15. It will be exactly 5,000 ft. in length. The contract for the construction of the inlet crib has been let for $24,000. The entire work will have cost about $135,000.

THE Mt. Pleasant Water Co., a corporation representing New York capital, has been building Water Works at Mt. Pleasant, Ia., under a franchise granted by that town. The cost of the works was $75,000, and the town pays $100 a year per hydrant. The stand-pipe system is employed, the source of supply being a large storage reservoir formed by damming a creek, from which water is raised by a large Blake pump. There are about six miles of cast-iron pipe. The firm of Inman Bros. had charge of the construction.

THE estimated cost of the Farm Pond conduit, Boston, was $89,100. The following bids were offered upon its construction:

George M. Cushing, New York	$68,459.80
Benjamin Heath, Jr., Boston	71,356.50
T. F. Brigham, Boston	74,142.00
Seth Perkins & John Mitchell Galvin, Boston.	74,913.80
Parker & Sylvester, Newton and Rockport	87,308.20
J. H. Lovett, Boston	89,852.50
Boynton Bros., Boston	98,730.00
Geo. H. Cavanaugh, Boston	100,040.00
C. J. Carmody & Co., Boston	102,817.00
Joseph J. Leighton, Boston	127,279.20

The contract was not awarded.

MESSRS. INMAN BROS. of 32 Liberty St., New York are at present engaged on a system of water-works for Prescott, a town of 6,000 inhabitants in Central Arizona. The plant consists of one large storage reservoir into which water is pumped from a creek by a Blake pump, steam being furnished from horizontal tube bar boilers manufactured in Boston.

There are in all about five miles of wrought-iron pipe, a part of which is a ten-inch main. This pipe makes a regular butt joint, surrounded by a cast-iron sleeve and packed with lead as in the joints of ordinary cast-iron pipes. Wrought iron was selected because of its greater lightness, a most important consideration, as Prescott is 50 miles from any railroad, and all material had to be hauled by miles at high freights The total cost of the works will be $65,000.

NEWS OF THE WEEK.

Miscellaneous.

THE public bridge at Selma, across the Alabama river, is to cost $47,000.

A CONTRACT for curbing was recently awarded to B. Krell & Co., Kansas City, Mo., at seventy-six cents per foot.

IT is expected that the electric light in the tower at Hallett's Point, Hell Gate, will be in operation before the close of the present month.

WORK is to be renewed immediately on the mines at Hell-Gate. Nine acres will be undermined and exploded at the same time by charges of dynamite.

A STREET paving contract in Minneapolis recently awarded to Wm. Forristall for $19,938, has been reconsidered. The city will re-advertise the contract.

A CALIFORNIA man has a 7 in. artesian well 840 ft. deep which yields excellent water. Within this is a 4 in. tube sunk to a depth of 1250 ft. which yields water strongly charged with hydrogen gas. The yield is sufficient to run a 20 H. P. engine.

EXPERIMENTS with the arc light by a committee of the Franklin Institute to decide the question as to whether it is sufficiently steady to be used for microscopic analysis have resulted favorably. The light was produced by the Brush system.

A PLAN for the re-organization of the Wabash, St. Louis and Pacific Railway is under active consideration by the Directors of the company. At the meeting on Wednesday, Jay Gould resigned the Presidency, and was succeeded by Jas. F. Joy, the former well known President of the Michigan Central.

CONTRACTS for building a new bridge over the Piscataquis, at East Dover, Me., have just been awarded. The bridge will be of iron, and manufactured by the Berlin Bridge Company of Connecticut. It will be one span, 150 feet. Should the season be favorable it is expected the bridge will be open for travel before winter.

DREDGING.—Abstract of proposals for dredging in Port Chester Harbor, N. Y.:

Richard Parrott, 16c. per cubic yard.
J. H. Fenner, 29c. cubic yard.
Edgar M. Payn, 29 9/10c. cubic yard.
John McDermott, 31½c. cubic yard.
Henry Du Bois' Sons, 32½c. cubic yard.
Elijah Brainard, 43c. cubic yard.
Contract awarded to Mr. Parrott.

REMOVAL OF WRECKS.—The following is an abstract of the bids received for the removal of wrecks at New Orleans, which were rejected by the Chief of Engineers:

James L. Burriss and Wm. E. Buck, for the removal of the Ailsa, $14,300; for the steamship General Grant, $17,700.

Rittenhouse Moore, removal of the steamship Gresham, $45,000; of the Ailas, $14,000; of the Grant, $12,000.

Peter E. Falcon, for the removal of the Gresham, $25,000.

SEWER PIPES, &C.—The following are the bids of Michael Shey for the construction of sewer pipe in the District of Columbus. Mr. Shey has been awarded the contract. Constructing 425 linear feet of 12 in. pipe sewer, including 2 manholes and appurtenances, $1.15 pr. lin. ft.; 325 linear feet of 18 in. pipe sewer, including 2 man holes and appurtenances, $1.35 pr. lin. ft.; constructing receiving basins, $45 each; 12 in. pipe connections with receiving basins, 80c pr. lin. ft.; 15 in. pipe connections with receiving basins, 80c pr. lin. ft.

STONE AND BRICK WORK.—The following is an abstract of the bids received for stone work of basement and superstructure of the custom house and post office at Pensacola, Fla.:

Gill & Beard, brownstone, total $107,653, estimate for stone work in dormers and tower, $20,000. Bowling Green, total $97,074; for dormers and tower, $18,135. Bedford, total $93,250; dormers and tower, $17,693.

A. V. Clubbs, Buena Vista freestone, total $72,000; for dormers and tower, $13,000.

Belknap & Dumesnil Stone Co., Bowling Green stone, total $66,950; dormers and tower, $12,850.

M. A. McGowan, Bowling Green or Buena Vista freestone, total $89,000; dormers and tower, $16,896. Brown stone, total $104,000; tower and dormers, $19,710.

John R. Smith, Connecticut brownstone, total, $83,950; dormers and towers, $18,000.

The contract has been awarded to Belknap & Dumesnil Stove Co., at their total bid of $66,950, less the $12,850 estimate for work on dormers and tower.

SOME of the statistics of Denver, Col., are: Total number of miles of main and district sewers, 25½; total number of miles of house drains, 15; total area in square feet embraced in sewer system, 21,164,622; total cost of main and district sewers, $329,474.47; total area in square miles of the city within corporate limits, 13½; total area of city in square miles including additions and town plats, 20⅔; total lineal miles of streets within corporate limits, 230; total lineal miles of alleys within corporate limits, 85; total lineal miles of sidewalks within corporate limits, 80.

THE steel rail works at Pennsylvania last year turned out 882,375 tons of Bessemer steel, which is about 40 per cent. of the total production. The Edgar Thomson works, located near Pittsburg, take the lead with a production of 300 tons per day of all kinds of steel, or 180,042 tons per annum. The Pennsylvania Company, near Harrisburg, follows with 171,989 tons. The Cambria Company, at Johnstown, comes third on the list with a production of 160,734 tons per annum. The production at Bethelehem was 153,098 tons. Bessemer steel is made at five other works in Pennsylvania.

WHEELING, West Va., Aug. 6.—This city is a total wreck financially, besides being saddled with a bonded debt of $700,000, which is about all it can carry under the law, which limits the issue of bonds to 45 per cent. of the total valuation. There are city orders to the amount of $160,000 outstanding. The treasury is empty, and many employés have had no pay for three months. Added to this, all the banks of the city have refused further advances, and the municipal machinery must run on credit for an indefinite period or come to a full stop. This condition of affairs has been brought about by two things, extravagance and waste in the conduct of the government and insufficient revenues to meet necessary expenses, interst on loans, etc. For the past four or five years there has been a deficit of $50,000 a year, which has been bonded. The deficit of this year will be twice that sum at least. Obligations are now maturing, and there are no funds to meet them. Policemen and firemen are compelled to go on the street to get their orders for pay cashed, money being forthcoming only at a heavy discount.

STREET IMPROVEMENTS.—The contracts for improving the streets of Washington have been awarded as follows:

To Maloney & Knight for asphalt block pavement on C street southeast, from New Jersey avenue to Fourth street; Fourth street northeast from East Capitol to Maryland avenue, at $2.10 per square yard.

To H. L. Cranford for sheet asphalt pavement on A street northeast from Second to Fourth; on B northeast from Second to Fourth; on Third northeast from East Capitol to Maryland avenue at $2.25 per square yard.

To the Barber Asphalt Pavement Company for sheet asphalt pavement on New Jersey avenue from L to New York avenue northwest; P street from New Jersey avenue to Ninth street northwest; P street from Fifteenth to Eighteenth northwest; R street from Ninth to Fourteenth northwest; L street from Pennsylvania avenue to Twenty-sixth street; Potomac street from Prospect to O street northwest; H street from Fourteenth to Fifteenth street; I street from Second to Fifth northwest; Third street from B to Virginia avenue southwest; Thirteenth from Colcoran to T street northwest, at $2.25 per sq. yd.

Railroads and Canals.

A CORPS of engineers are surveying a line of road from Rome, Ga., to Chattanooga.

SURVEYS have been completed for a canal from the German Ocean to the Baltic Sea.

THE engines for the Kansas City cable railway are being built in Baltimore.

A STREET railway line is to be built from San Luis Potosi to Tequiquipam.

THE East and West railroad, of Alabama, has been built from Cartersville, Ga., to Broken Arrow, Ala., and is now in operation.

THE Flemington branch of the Easton and Amboy Division of the Lehigh Valley railroad was opened August 4th.

Contracts have been made to extend the Wisconsin, Iowa and Nebraska road 25 miles south of Leon, Ia.

THE Andine Railroad—a line running from Buenos Ayres to Mendoga at the base of the Andes, has been completed.

WORK is being pushed rapidly on the Park River extension of the St. Paul, Minneapolis and Manitoba Railroad. From 75 to 85 miles of track will be laid.

CONSTRUCTION, it is said, will be begun on the Mexican National in September, and will not cease until the line is completed from Santillo to the capital.

THE railroad from Bangor, Me., to Oldtown was one of the first built in this country. It commenced operations in 1832, and was known as the Veavie road.

THE electric motor on the Cleveland street railway is making regular trips, propelling itself and one attached car at the rate of 8 miles an hour.

THE injunction against the Reading and Pottsville road for which the P. & R. petitioned some time ago has been denied, and the former road will at once commence construction.

ALBUQUERQUE, N. M., July 29.—The great bridge over Colorado River, at the Needles, California, on the Atlantic and Pacific railroad, was completed to-day.

NEARLY all the money necessary for the commencement of work on the Chesapeake and Nashville R. R., has been subscribed. A $300,000 bridge across the Cumberland will be built.

THE Manchester ship-canal bill was rejected because the committee having it in charge though it would greatly injure the interests of Liverpool. The expenses of the promoters and opponents of the scheme aggregate £260,000.

THE new iron bridge near Zanesville, over Eagle Creek, on the Cincinnati, Indianapolis, St. Louis and Chicago Road, was on Sunday evening, July 27th, swung into position, and on Monday trains began running over it.

THE Brooklyn elevated road is being boomed again. The firm ofC ooper, Hewitt & Co, have undertaken to furnish the iron at the rate of 60 tons a day. Negotiations for the rolling stock and other equipments are also under way.

THE work of laying the track of the Jacksonville, St. Augustine and Halifax River Railway to the west end of the new mammoth hotel at St. Augustine, Fla., was commenced recently but has been stopped by an injunction from property-holders.

A LARGE corps of engineers has been put to work upon the survey of the extension of the Grafton and Greenbrier road from Phillipi to Beverly, in Randolph County, W. Va. This road is a feeder to the Baltimore and Ohio, and will penetrate the largest and most valuable coal fields in the state.

A TRIAL has been made in Manchester, Eng., of an electric train-car, very similar to that running at Cleveland, Ohio, except that the main conductor of the current is above ground instead of being submerged. The inventor, Mr. M. H. Smith of Halifax, Eng, claims that cars can be run at one fifth the cost of propulsion by horses.

THE Duluth and Manitoba Railroad Company which was incorporated to connect the Northern Pacific with Crookston and Grand Forks, is moving ahead rapidly. The capital is $2,000,000, and it will doubtless soon be subscribed. It is expected to complete the road to Red Lake Falls this season.

CAPE GIRARDEAU, Mo., August 1.—Capt. Healey and his corps of surveyers of the Illinois Central Railroad arrived here last night, after completing the second route from Wetang to this place. They report this last as the more favorable route. They left this morning to run a line from there to Anna, Ill. before reporting to headquarters.

THE projected road, known as the Columbus, Fort Wayne and Western, noticed in ENGINEERING NEWS of July, 26th is to connect the Chesapeake and Ohio system with Lake Michigan. McConnellsville, O., and Benton Harbor on the shore of Lake Michigan are its termini. Work has commenced at the McConnellsville end.

THE Broadway (N. Y.) Surface Railroad Company on Wednesday, were given the franchise of Broadway for a horse car line from the Battery to the junction of the Seventh Ave. line at 15th street. The franchise was presented by the liberal New York aldermen, although $1,000,000 was offered for it not a very long time ago.

PORTLAND, DAK., July 31.—The line from Portland to Larimore is now completed. It is built entirely with steel rails and new ties, with oak ties for coupling. The construction train is now laying the track into Wayville from the junction, but using old ties and refuse rails, some pieces being only ten feet long. They expect to have it also completed this week.

A CERTIFICATE of incorporation has been issued to the Kansas City and Independence Railway company. The capital stock is $100,000. The proposed road is to be standard gauge, ten miles in length, running from Kansas City to Independence. The stock is divided into shares of $100 each, and held as follows: J. Smith, 500 shares; Robert Gillham, 497 shares; George Shiedley, William H. Lucas and William M. Hall, one share each.

AT a meeting of Directors in London, Eng., on the 6th the arrangements for pushing the construction of the Gravenhurst and Callender Railway, Ont., were sanctioned and the branch will be built as speedily as possible. The road will connect the Ontario system of railroads with the Canadian Pacific Railway at Callender, and bring Toronto and the western part of the Province in direct communication with Winnipeg instead of forcing traffic east as far as Ottawa, as was purposed by the Canadian Pacific Company.

THE Terre Haute and Logansport extension runs from Logansport, Ind., to South Bend, a distance of 67 miles. Grading has been completed along nearly the whole line, and track laying along all but the last 10 miles. The work of building this extension has been very thoroughly done, the maximum grade being 26.4 ft. per mile, except going out of the Wabash valley at Logansport, where it is 40 ft. per mile. Maximum curvature, 3° (1,910 ft. radius); 2,800 white or burr oak ties per mile; 60 pound steel rails, reinforced angle splices, split switches, and steel-rail spring frogs, and all work of track superstructure of the very best. Mr. A. Fitch is chief engineer.

AN open movement has begun in Haverhill for the extension of the Lowell and Lawrence Railroad to that city. The proposed route is through Methuen, on the northern bank of the Merrimack to Gage's Ferry, where it will cross the river and run across "Bradford Neck" at Mitchell's Falls, where it is proposed to found a new city. It will then recross the river and thread its way through a valley, also crossing Carleton Street and Broadway under grade, entering the city on Winter Street, and reaching its terminus at the corner of Emerson and Walnut Streets, with an approach to the station directly from Washington Square in the heart of the city.

THE articles of incorporation of the Lexington Avenue and Fourteenth street Railroad Company, with a capital of $1,000,000, have been filed at Albany. It is proposed to run the road through Lexington Avenue from Ninety-seventh street to Twenty-third street, which it is to traverse to Fourth Avenue, thence to Fourteenth street, where it is to terminate. It is to be double tracked. As soon as Lexington Avenue is opened to the Harlem River the road will be continued northward. The Trustees are John Downey, George W. Lynch, Charles Curtis, Lewis May, George W. Conner, Isaac Hendrix, and Thomson Rogers. It is to be a horse and not a cable road. The company is not yet organized, and no stock has been issued. The cost of the plant is estimated at over $1,000,000.

THE GUATEMALA NORTHERN.—Señor Angel Pena, President of the Gautemala Northern Railroad, writes by the last steamer as follows: "The contractors, Lyman & Gordon, of New York, have already given the bond of $100,000 required by their contract, and they are prepared to commence the work agreeably to the terms stipulated. Three miles have already been graded, the locomotives and cars are in complete order, and the first 200 tons of rails are now being landed at the port of Barrios. All this shows that the undertaking I have the honor to conduct is an accomplished fact. The contract for building the station has been awarded to L'Hote & Co., of New Orleans, and a portion of the same has been shipped to its destination. The contract of Lyman & Gordon embraces all the road from the port of Barrios to the capital."

PLANS FOR A BRIDGE.—READING, Penn., Aug. 6.—Engineer Crawford, of the Pennsylvania and Schuylkill Valley Road, this afternoon met the County Commissioners and Board of Trade and submitted plans for the new iron bridge to cross the Schuykill at the foot of Penn street, with an overhead approach for the purpose of avoiding a crossing at the grade on Front street, where already are the tracks of the Wilmington and Berks and Lehigh Railroads. The bridge is to be 1,100 ft. long. The company proposed that the bridge should have a 26 ft. roadway and 4 ft. footway on either side, which would make it cost about $100,000, if the Commissioners of the county would give $30,000 toward the expense, or 21 ft. roadway, the county to pay $20,000. The first proposition was accepted.

SALT LAKE, August 4.—The Butte and Atlantic Railroad Company has filed articles of incorporation. It is composed of some of the most substantial citizens of Butte, Dillon and Virginia City. The road is to begin at Gallatin Station and run to Butte, with branches from the main line to Dillon and Virginia City. The main line is to be seventy-two miles long.

MR. J. D. TRAMMELL and his corps of engineers have completed their preliminary survey of the Georgia Midland railway, from Columbus to Atlanta. Under this survey the distance between Atlanta and Columbus will be 104 miles. The engineering corps, it is said, will now proceed to Griffin and run a preliminary line from there to some point, say Flint River, to intersect the line now surveyed between Atlanta and Columbus. The officers of the Georgia Midland are: President, J. W. Woodfolk; secretary, C. L. Davis; directors, Dr. N. J. Bussey, George C. Swift, Jr., G. Gunby Jordan, T. E. Blanchard, M. E. Gray, B. T. Hatcher, John F. Flournoy, C. L. Davis.

Estimates of the cost of building the road will soon be furnished by the engineer, and it is believed that the actual work of construction will begin in the course of a few weeks.

A SYNDICATE, embracing the Hon. Alexander MacNab, of London, England; I. A. Stearns and L. J. Shoemaker, of Wilkesbarre, Pa; H. M. Munsell and Edwin H. Trafton, of New York; R. Gray, of Pennsylvania; A. C. Apgar, of Trenton, N. J., and John R. Bothwell, of New York, has been formed for the purpose of building a railroad from Cheyenne to the Yellowstone National Park. They have organized a company called the Wyoming and Yellowstone Park Railroad and Development Company, with a capital of $10,000,000, and it is understood that this company will amalgamate the Cheyenne, Black Hills and Montana Railroad Company, which was organized about three months ago, but which has not as yet built any road. The enterprise is considered well based and is regarded as the largest and most important of any seen in Wyoming since the building of the Union Pacific.

THE Third Avenue Railroad Company, N. Y. is building a cable surface railroad which, when finished, will extend from East River to North River on 125th Street, and from 125th Street to 187th street on Tenth Avenue. Mr. D. J. Miller, who made the plans for the cable railway in Chicago, is the chief engineer of this road. He said:

"This railway will be somewhat different from any other in the world. It is an improvement on the Chicago cable road for several reasons. In the first place it is planned on a duplicate system—that is, there are two cables working in the same way on each track; while one is in use the other is not; but in case of accident to the one in use, it would take only two minutes to transfer the brake to the other, and the delay would be hardly noticeable. In the second place, the pulley wheels which move the cable, are placed in vaults just 35 ft. apart and 22 in. square. Now, the tracks are so formed that, in case of rain, the water will be stopped by them instead of flowing toward the curbstone, and will sink into these vaults. To take away this water a sewer pipe 6 in. in diameter will run the whole length of the road, underground. The whole road will be composed of steel, iron, and concrete, no wood being used, because wood rots. Our cars will be running early in October."

CAPTAIN W. J. KIRK, chief engineer of the Greenville and Laurens railroad of South Carolina completed his preliminary survey of a line from Greenville to the top of the mountains recently, and lately made his report to Mr. John Ferguson, chairman of the committee under whose guidance he had been instructed to act by President Mauldin. The report is brief and contains the following facts and figures. The survey was begun on the track of the Spartanburg and Asheville railroad at Butt mountain gap. The best practical line was surveyed from that gap to a point in Greenville county, near John H. Gooodwin's, about twenty-five miles from the city of Greenville. From the foot of the mountains to Greenville three routes were surveyed, that by Marietta being found the cheapest. Taking the estimates of the Marietta route the whole line from Greenville to Butt mountain gap, which is two and a half miles south of Flat Rock, and five miles south of Hendersonville, North Carolina, counting the cost of grading, culverts and trestling, is stated as follows: Greenville division, ending at J. H. Goodwin's, twenty-four and one-tenths miles, $93,700; thence to the North Carolina line, 15½ miles, $390,000; from the North Carolina line to Butt mountain gap, 6½ miles, $71,900, making the total line of a little over 45 miles, cash in round numbers, the sum of $550,000.

Army and Navy News.

WASHINGTON, Aug. 3.—By the direction of the Secretary of War the following changes in the stations and duties of officers of the Corps of Engineers are ordered: Capt. Frederick A. Mahan to Willett's Point, N. Y., and report to Lieut-Col. H. L. Abbot, for duty with the battalion of Engineers; Capt. Ernest H. Ruffner, Willett's Point, N. Y., ordered to Rock Island and relieve Major Alexander Mackenzie; Capt. Eric B egland to Vicksburg, relieving Major A. M. Miller; Capt. W. T. Russell to Jacksonville, Fla., relieving Col. Gillmore; Capt. Richard L. Hoxie to Montgomery, Ala., relieving Major W. R. King and Major A. N. Damrel; Capt. W. H. Bixby to Wilmington, N. C., relieving Capt. F. A. Hinman; Major M. B. Adams to San Francisco, relieving Major W. A. Jones; Major Jones, on being thus relieved, will proceed to and take station at Portland, Oregon, relieving Capt. C. F. Powell; Lieut. C. McD. Townsend to Washington and report to the Engineer Commissioner; Lieut F. V. Abbot to New York City and report to Col. Quincy A. Gillmore; Lieut. M. Carter to New York City and report to Col. Quincy A. Gillmore: Lieut. J. G. Warren to Chattanooga, Tenn., and report to Major W. R. King.

Col. Hains, of the Corps of Engineers, has made his annual report upon the fortification of the Potomac River to Gen. Newton, Chief of Engineers. The forts constituting the defense of the national capital are Forts Washington and Foote, situated on the Potomac, below the city. Both of these, Col. Hains says, are in an utterly useless condition. The construction of Fort Washington was begun in 1816. The masonry is still in good condition, but it is not adapted to receive guns of modern style, or for defensive purposes against such guns. In 1872 it was intended to convert the demilune into a battery of modern construction, with guns of larger calibre. The platforms for four of these guns were built and the magazines partially constructed, when the work was suspended for lack of funds. At the present time the defenses at Fort Washington consist of four 15-inch gun platforms, without a parapet in front of them and without magazines. Fort Foote was constructed in 1862. No improvement has been made within the past 10 years. There are five gun platforms laid, four front and one centre pintle. They are built of concrete and granite, and mounted. The buildings are constructed of perishable material and are fast going to decay. Col. Hains ask for an appropriation of $100,000 for the next fiscal yeai for the improvement of the two forts.

The Chief Engineer of the army has received the annual reports of all the engineer officers in charge of coast and harbor defenses. They reiterate their assertion of last year, that the Atlantic coast and lake fronts are in an almost totally defenseless condition. The majority of the defenses are said to be falling into decay, and the armament in most instances is so far behind the times as to be utterly worthless. Gen. Newton, it is understood, will in his annual report urge immediate provision for the adequate protection of harbors by batteries and fortifications of modern design.

Colonel T. L. Casey, U. S. Army, the officer in charge of the construction of the Washington monument, has prepared a set of photographs showing the appearance of the monument at different stages from the beginning of the work up to the present time, and also a picture of the shaft as it will be when completed. These mounted and framed will be sent as an exhibit to the New Orleans Cotton Centennial Exhibition, together with explanatory documents.

In his report of the improvement of the Potomac flats Col. Hains calls attention to the necessity of a change in the Long Bridge, and says that while it remains no plan of improvement can be made satisfactory. As it is at present it retards the flow of water, and will cause the dredged channel to fill again. If it is not to be rebuilt on new piers, with wide spans, it should be put in condition to prevent damage to city property in time of freshet by removing 400 ft. of the causeway at the south end and deepening the water between the piers northeast of the draw; but the only radical cure is a new bridge with wider spans.

ENGINEERING NEWS will soon publish illustrated descriptions of the Gatling, Nordenfeldt and other notable guns, also accounts of the most recent improvements in the artillery practice of European nations.

AN OPPORTUNITY.

I want a responsible party, the more practical the better, to engage in the construction of my new Steam Excavator.

I have made experiments to prove its efficiency, and will guarantee the machine to be as good as the best in the market, at much less cost of construction than any excavator built of like capacity,

Plans and estimates of cost of complete machine ready for inspection. I will give good terms to the party taking hold of the enterprise with me.

I have had fourteen years experience in handling earthwork, both as Engineer in charge of Constuction, and as Contractor, and I know what machinery is required for such service. I refer to any Civil Engineer in St. Paul.

VINE D. SIMAR, C. E.

20— P. O. Box 2298, St. Paul, Minn

PROPOSALS.

Proposals for Furnishing Cast-Iron Water Pipes and Special Castings.

OFFICE OF THE ENGINEER COMMISSIONER, WASHINGTON, D. C., Aug. 6, 1884.

BY direction of the Board of Commissioners, sealed proposals will be received at this office until 12 o'clock noon, on Wednesday, **August 20, 1884**, for furnishing 945 tons, more or less, of cast-iron water pipes and special castings for the same.

For specifications, blanks, on which bids must be made, and all other information, apply at this office.

G. J. LYDECKER,
Major of Engineers, U. S. A.,
6—2t. Engineer Commissioner, D. C.

Proposals for the Construction of Sewers.

OFFICE OF THE ENGINEER COMMISSIONER, WASHINGTON, D. C., July 31, 1884.

BY direction of the Board of Commissioners, sealed proposals will be received at this office until 12 o'clock M. on **Saturday, August 16, 1884**, for constructing in the City of Washington, District of Columbia, Terra Cotta Pipe Sewers from 12 to 24 in. in diameter, and Brick and Concrete Sewers and reconstructing the main Georgetown Sewer.

Blank forms of proposals and specifications can be obtained at this office upon application therefor, together with all necessary information, and bids upon these forms will alone be considered.

The right is reserved to reject any and all bids or parts of bids.

(Signed) G. J. LYDECKER,
Major of Engineers, U. S. A.,
6-1t. and Engineer Commissioner, D. C.

Improving Cape Fear River below Wilmington, N. C.

PROPOSALS FOR DREDGING.

U. S. ENGINEER OFFICE, 70 Saratoga Street, BALTIMORE, MD., July 24, 1884.

PROPOSALS for Dredging in Cape Fear River, N. C., will be received until eleven o'clock A.M., August 28, 1884, and opened immediately thereafter.

Blank forms, and specifications can be had upon application to this office.

WM. P. CRAIGHILL, Lt.-Col. of Eng'rs, U. S. Army.
5-4t

Improving Cape Fear River below Wilmington, N. C.

Proposals for Furnishing Stone.

U. S. ENGINEER OFFICE, 70 Saratoga Street, BALTIMORE, MD., July 24, 1884.

PROPOSALS for furnishing 30,000 tons of Stone for the improvement of the Cape Fear River, North Carolina, will be received until noon August 28, 1884, and opened immediately thereafter.

Blank forms and specifications, etc., can be had upon application to this office, or to the resident Engineer, Mr. HENRY BACON, at Wilmington, N. C.

WM. P. CRAIGHILL, Lt.-Col. of Eng'rs, U. S. Army.
5—4t.